DEPARTMENT OF CHEMICAL ENGINEERING
ANNA UNIVERSITY, CHENNAI

VISION:

To be recognized globally and to function as a catalyst in providing outstanding education, to develop engineers who will excel in academia, industry, and research, and to strive for sustainable technologies and societal needs.

MISSION:

1. To disseminate high-quality Chemical Engineering Education.
2. To develop quality engineers and technocrats with inter-disciplinary skills.
3. To collaborate with industries for innovative concepts/ideas.
4. To perform high-impact research for the benefit of society.

ANNA UNIVERSITY: : CHENNAI: 600 025
UNIVERSITY DEPARTMENTS
M. TECH. CHEMICAL ENGINEERING
REGULATIONS – 2023
CHOICE BASED CREDIT SYSTEM

1. PROGRAMME EDUCATIONAL OBJECTIVES (PEOs)

I.	Develop, analyze, and solve critical chemical engineering problems, and to pursue advanced study or research.
II.	Design and evaluate technical concepts to produce new products and answers to real-world challenges.
III.	Work in groups on multidisciplinary projects and in a diversified professional context.
IV.	Cultivate sustained knowledge on skill development and industrial needs.
V.	Deliver sustainable solutions to chemical engineering challenges to meet the needs of industry and society on a global scale.

2. PROGRAMME OUTCOMES (POs)

PO	PROGRAMME OUTCOMES
PO1	Ability to independently carry out research/investigation and development work to solve practical problems
PO2	Ability to write and present a substantial technical report/document
PO3	Able to demonstrate a degree of mastery over the area as per the specialization of the programme. The mastery shall be at a level higher than the requirements in the appropriate bachelor programme.
PO4	Able to exhibit professional development in the design, modelling, simulation, and optimization of chemical products and processes.
PO5	Able to plan and perform experiments, analyse data, interpret for finding optimal solutions.
PO6	Attainment of a scholastic approach to higher education, work, and entrepreneurship.

3. MAPPING OF PROGRAMME EDUCATIONAL OBJECTIVE WITH PROGRAMME OUTCOMES

PROGRAMME EDUCATIONAL OBJECTIVES	PROGRAMME OUTCOMES					
	PO1	PO2	PO3	PO4	PO5	PO6
I.	3	2	1	2	3	2
II.	3	1	3	2	1	1
III.	1	2	1	2	2	1
IV.	1	1	2	2	2	3
V.	1	1	1	2	3	3

4. PROGRAMME ARTICULATION MATRIX

YEAR	SEMESTER	COURSE NAME	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
I	I	Advanced Numerical Methods	3	-	3	3	2	2
		Research Methodology and IPR	3	3	1	-	-	-
		Advanced Transport Phenomena	3	1	3	3	2	1
		Advanced Reaction Engineering	3	3	2	2	1	2
		Advanced Process Control	2.38	1.63	2.75	3	2.5	1.5
		Chemical Process Design	3	3	1.4	3	2.8	3
		Program Elective I						
		Program Elective II						
	II	Separation Processes	2	1.5	1.63	1.88	1.5	2.13
		Software applications in Chemical Industries	1.8	2.4	2.8	3	2.8	-
		Advanced Thermodynamics for Chemical Engineers	2.8	3	3	3	3	1.6
		Chemical Process Optimization	3	1	2	3	3	1.2
		Program Elective III						
		Program Elective IV						
		Mini Project with Seminar	3	3	3	3	2	1
II	III	Modeling of Chemical Processes	3	2	3	3	2	1
		Program Elective V						
		Program Elective VI						
		Program Elective VII						
		Project Work I	2.75	2.5	2.25	1.75	1.75	2
	IV	Project Work II	3	2.33	2	2	1.67	2
			2.75	2.5	2.25	1.75	1.75	2

1, 2 and 3 are correlation levels with weightings as Slight (Low), Moderate (Medium) and Substantial (High) respectively.

ANNA UNIVERSITY, CHENNAI
UNIVERSITY DEPARTMENTS
M. TECH. CHEMICAL ENGINEERING
REGULATIONS – 2023
CHOICE BASED CREDIT SYSTEM
I TO IV SEMESTERS CURRICULA & SYLLABI

SEMESTER I

S. NO.	COURSE CODE	COURSE TITLE	CATEGORY	PERIODS PER WEEK			TOTAL CONTACT PERIODS	CREDITS
				L	T	P		
THEORY								
1.	MA3155	Advanced Numerical Methods	FC	4	0	0	4	4
2.	RM3151	Research Methodology and IPR	RMC	2	1	0	3	3
3.	CL3101	Advanced Transport Phenomena	PCC	3	0	0	3	3
4.	CL3102	Advanced Reaction Engineering	PCC	3	0	0	3	3
5.	CL3103	Advanced Process Control	PCC	2	0	2	4	3
6.	CL3104	Chemical Process Design	PCC	3	0	0	3	3
7.		Professional Elective I	PEC	3	0	0	3	3
8.		Professional Elective II	PEC	3	0	0	3	3
			TOTAL	**23**	**1**	**2**	**26**	**25**

SEMESTER II

S. NO.	COURSE CODE	COURSE TITLE	CATEGORY	PERIODS PER WEEK			TOTAL CONTACT PERIODS	CREDITS
				L	T	P		
THEORY								
1.	CL3201	Separation Processes	PCC	2	0	2	4	3
2.	CL3202	Software Applications in Chemical Industries	PCC	2	0	2	4	3
3.	CL3203	Advanced Thermodynamics for Chemical Engineers	PCC	3	0	0	3	3
4.	CL3204	Chemical Process Optimization	PCC	3	0	0	3	3
5.		Professional Elective III	PEC	3	0	0	3	3
6.		Professional Elective IV	PEC	3	0	0	3	3
PRACTICALS								
7.	CL3211	Mini Project with Seminar	EEC	0	0	2	2	1
			TOTAL	**16**	**0**	**6**	**22**	**19**

SEMESTER III

S. NO.	COURSE CODE	COURSE TITLE	CATEGORY	PERIODS PER WEEK L	T	P	TOTAL CONTACT PERIODS	CREDITS
THEORY								
1.	CL 3301	Modelling of Chemical Processes	PCC	3	1	0	4	4
2.		Professional Elective V	PEC	3	0	0	3	3
3.		Professional Elective VI	PEC	3	0	0	3	3
4.		Professional Elective VII	PEC	3	0	0	3	3
PRACTICALS								
5.	CL3311	Project Work I	EEC	0	0	12	12	6
			TOTAL	**12**	**1**	**12**	**25**	**19**

SEMESTER IV

S. NO.	COURSE CODE	COURSE TITLE	CATEGORY	PERIODS PER WEEK L	T	P	TOTAL CONTACT PERIODS	CREDITS
PRACTICALS								
1.	CL3411	Project Work II	EEC	0	0	24	24	12
			TOTAL	**0**	**0**	**24**	**24**	**12**

TOTAL CREDITS: 75

FOUNDATION COURSES (FC)

S. NO	COURSE CODE	COURSE TITLE	PERIODS PER WEEK			CREDITS
			Lecture	Tutorial	Practical	
1.	MA3155	Advanced Numerical Methods	4	0	0	4
			TOTAL CREDITS			**4**

LIST OF PROFESSIONAL CORE COURSES (PCC)

S. NO	COURSE CODE	COURSE TITLE	PERIODS PER WEEK			CREDITS
			Lecture	Tutorial	Practical	
1.	CL3101	Advanced Transport Phenomena	3	0	0	3
2.	CL3102	Advanced Reaction Engineering	3	0	0	3
3.	CL3103	Advanced Process Control	2	0	2	3
4.	CL3104	Chemical Process Design	3	0	0	3
5.	CL3201	Separation Processes	2	0	2	3
6.	CL3202	Software applications in Chemical Industries	2	0	2	3
7.	CL3203	Advanced Thermodynamics for Chemical Engineers	3	0	0	3
8.	CL3204	Chemical Process Optimization	3	0	0	3

9.	CL 3301	Modelling of Chemical Processes	3	1	0	4
				TOTAL CREDITS		28

PROFESSIONAL ELECTIVE COURSES

S. NO.	COURSE CODE	COURSE TITLE	CATEGORY	PERIODS PER WEEK			TOTAL CONTACT PERIODS	CREDITS
				L	T	P		
1.	CL3001	Biochemical Engineering	PEC	3	0	0	3	3
2.	CL3002	Waste to Energy	PEC	3	0	0	3	3
3.	CL3003	Membrane Separation Processes	PEC	3	0	0	3	3
4.	CL3053	Fluidization Engineering	PEC	3	0	0	3	3
5.	PP3251	Multicomponent Distillation	PEC	3	0	0	3	3
6.	CL3004	Nanocomposites	PEC	3	0	0	3	3
7.	CL3005	Thermal processing of food Products	PEC	3	0	0	3	3
8.	CL3006	Bioprocess Technology	PEC	3	0	0	3	3
9.	CL3051	Computational Fluid Dynamics	PEC	3	0	0	3	3
10.	CL3052	Design of Experiments	PEC	2	0	2	4	3
11.	CL3055	Sustainable Management	PEC	3	0	0	3	3
12.	PP3051	Multiphase flow	PEC	3	0	0	3	3
13.	CL3056	Polymer Processing Technology	PEC	3	0	0	3	3
14.	CL3007	Business Analytics	PEC	3	0	0	3	3
15.	CL3008	Chemical Processes and Pollution Control	PEC	3	0	0	3	3
16.	CL3009	Risk Analysis and Management	PEC	3	0	0	3	3
17.	CL3010	Project Engineering of Process Plants	PEC	3	0	0	3	3
18.	CL3011	Operations Research	PEC	3	0	0	3	3
19.	CL3012	Safety and Environment in Chemical Industries	PEC	3	0	0	3	3
20.	CL3013	Biomass Conversion Techniques	PEC	3	0	0	3	3
21.	EV3051	Electrochemical Environmental Technology	PEC	3	0	0	3	3
22.	CL3054	Industrial Instrumentation	PEC	3	0	0	3	3
23.	PP3052	Piping and Instrumentation	PEC	3	0	0	3	3

RESEARCH METHODOLGY AND IPR COURSES (RMC)

S. NO	COURSE CODE	COURSE TITLE	PERIODS PER WEEK			CREDITS
			Lecture	Tutorial	Practical	
1.	RM3151	Research Methodology and IPR	2	1	0	3

LIST OF EMPLOYABILITY ENHANCEMENT COURSES (EEC)

S. NO	COURSE CODE	COURSE TITLE	PERIODS PER WEEK			CREDITS
			Lecture	Tutorial	Practical	
1.	CL3211	Mini Project with Seminar	0	0	2	1
2.	CL3311	Project Work I	0	0	12	6
3.	CL3411	Project Work II	0	0	24	12
					TOTAL CREDITS	**19**

SUMMARY

	Name of the Programme: M.Tech. Chemical Engineering					
	SUBJECT AREA	**CREDITS PER SEMESTER**				**CREDITS TOTAL**
		I	**II**	**III**	**IV**	
1.	FC	4	-	-	-	4
2.	PCC	12	12	4	-	28
3.	PEC	6	6	9	-	21
4.	RMC	3	-	-	-	3
5.	EEC	-	1	6	12	19
6.	**TOTAL CREDIT**	**25**	**19**	**19**	**12**	**75**

MA3155 ADVANCED NUMERICAL METHODS

L	T	P	C
4	0	0	4

OBJECTIVES:

- To make the students understand the methods/algorithms to numerically solve a system of simultaneous algebraic equations.
- To make the students understand the methods to numerically solve the system of simultaneous ordinary differential equations.
- To make the students understand the methods to numerically solve the partial differential equations.
- To make the students understand the methods to numerically solve the elliptic equations.
- To make the students understand the finite element methods for solving the PDEs.

UNIT I ALGEBRAICEQUATIONS 12

Systems of linear equations: Gauss Elimination method, pivoting techniques, Thomas algorithm for tridiagonal system – Jacobi, Gauss Seidel, SOR iteration methods - Systems of nonlinear equations: Fixed point iterations, Newton Method, Eigenvalue problems: power method, Faddeev – Leverrier Method.

UNIT II ORDINARY DIFFERENTIAL EQUATIONS 12

Runge Kutta Methods for system of IVPs, numerical stability, Adams-Bashforth multistep method, solution of stiff ODEs, shooting method, BVP: Finite difference method, collocation method, orthogonal collocation method, Galerkin finite element method

UNIT III FINITE DIFFERENCE METHOD FOR TIME DEPENDENT PARTIAL DIFFERENTIAL EQUATION 12

Parabolic equations: explicit and implicit finite difference methods, weighted average approximation - Dirichlet and Neumann conditions – Two dimensional parabolic equations – ADI method; First order hyperbolic equations – method of characteristics, Lax-Wendroff explicit and implicit methods; numerical stability analysis, method of lines – Wave equation: Explicit scheme- Stability of above schemes

UNIT IV FINITE DIFFERENCE METHODS FOR ELLIPTIC EQUATIONS 12

Laplace and Poisson's equations in a rectangular region: Five point finite difference schemes, Leibmann's iterative methods, Dirichlet and Neumann conditions – Laplace equation in polar coordinates: finite difference schemes – approximation of derivatives near a curved boundary while using a square mesh.

UNIT V FINITE ELEMENT METHOD 12

Partial differential equations – Finite element method - collocation method, orthogonal collocation method, Galerkin finite element method.

TOTAL: 60 PERIODS

OUTCOMES:

At the end of the course, students will be able to

CO1 Solve numerically system of simultaneous algebraic equations.
CO2 Solve the simultaneous ordinary differential equations (IVP) numerically.
CO3 Solve numerically set of Partial differential equations.
CO4 Solve the set of Elliptic equations numerically.
CO5 Solve the set of PDEs by finite element method.

REFERENCES:

1. Burden. R. L. and Faires. J. D., "Numerical Analysis; Theory and Applications", India Edition, Cengage Learning, 2010.
2. Jain M.K., Iyengar S.R.K. and Jain R.K., Computational Methods for Partial Differential Equations, New Age International, 2nd Edition, New Delhi, 2016.

3. Morton K.W., and Mayers D.F., “Numerical Solution of Partial Differential Equations, Cambridge University Press, Second Edition, Cambridge, 2005.
4. Santosh K Gupta, “Numerical Methods for Engineers”, New Age International (P) Limited, Publishers, New Delhi, 2014.
5. Sastry S.S., "Introductory Methods of Numerical Analysis", Prentice - Hall of India Pvt. Limited, 5th Edition, New Delhi, 2012.
6. Saumyen Guha and Rajesh Srivastava, “Numerical methods for Engineering and Science”, Oxford Higher Education, New Delhi, 2010.

CO-PO Mapping:

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	3	3	3	2	2
CO2	3	3	3	3	2	2
CO3	3	3	3	3	2	2
CO4	3	3	3	3	2	2
CO5	3	3	3	3	2	2
Avg	3	3	3	3	2	2

RM3151 RESEARCH METHODOLOGY AND IPR L T P C
2 1 0 3

OBJECTIVES:

To impart knowledge on

- Formulation of research problems, design of experiment, collection of data, interpretation and presentation of result
- Intellectual property rights, patenting and licensing

UNIT I RESEARCH PROBLEM FORMULATION 9

Objectives of research, types of research, research process, approaches to research; conducting literature review- information sources, information retrieval, tools for identifying literature, Indexing and abstracting services, Citation indexes, summarizing the review, critical review, identifying research gap, conceptualizing and hypothesizing the research gap

UNIT II RESEARCH DESIGN AND DATA COLLECTION 9

Statistical design of experiments- types and principles; data types & classification; data collection - methods and tools

UNIT III DATA ANALYSIS, INTERPRETATION AND REPORTING 9

Sampling, sampling error, measures of central tendency and variation,; test of hypothesis- concepts; data presentation- types of tables and illustrations; guidelines for writing the abstract, introduction, methodology, results and discussion, conclusion sections of a manuscript; guidelines for writing thesis, research proposal; References – Styles and methods, Citation and listing system of documents; plagiarism, ethical considerations in research

UNIT IV INTELLECTUAL PROPERTY RIGHTS 9

Concept of IPR, types of IPR – Patent, Designs, Trademarks and Trade secrets, Geographical indications, Copy rights, applicability of these IPR; , IPR & biodiversity; IPR development process, role of WIPO and WTO in IPR establishments, common rules of IPR practices, types and features of IPR agreement, functions of UNESCO in IPR maintenance.

UNIT V PATENTS 9

Patents – objectives and benefits of patent, concept, features of patent, inventive steps, specifications, types of patent application; patenting process - patent filling, examination of patent, grant of patent, revocation; equitable assignments; Licenses, licensing of patents; patent agents, registration of patent agents.

TOTAL: 45 PERIODS

COURSE OUTCOMES

Upon completion of the course, the student can

CO1: Describe different types of research; identify, review and define the research problem

CO2: Select suitable design of experiment s; describe types of data and the tools for collection of data

CO3: Explain the process of data analysis; interpret and present the result in suitable form

CO4: Explain about Intellectual property rights, types and procedures

CO5: Execute patent filing and licensing

REFERENCES:

1. Cooper Donald R, Schindler Pamela S and Sharma JK, “Business Research Methods”, Tata McGraw Hill Education, 11e (2012).
2. Soumitro Banerjee, “Research methodology for natural sciences”, IISc Press, Kolkata, 2022,
3. Catherine J. Holland, “Intellectual property: Patents, Trademarks, Copyrights, Trade Secrets”, Entrepreneur Press, 2007.
4. David Hunt, Long Nguyen, Matthew Rodgers, “Patent searching: tools & techniques”, Wiley, 2007.
5. The Institute of Company Secretaries of India, Statutory body under an Act of parliament, “Professional Programme Intellectual Property Rights, Law and practice”, September 2013.

CL3101	**ADVANCED TRANSPORT PHENOMENA**	**L**	**T**	**P**	**C**
		3	**0**	**0**	**3**

OBJECTIVES:

- To impart knowledge on the concepts of transport phenomena and its relationships with other core chemical engineering subjects.
- To make the students to develop governing equations for complex system in chemical engineering
- To make the students to learn solution techniques in momentum, energy and mass transport phenomena.
- To help the students to understand the flow behavior in different systems
- To make the students to develop critical thinking skills, interpret physicochemical phenomena to and from mathematical expressions.

UNIT I BASIC CONCEPTS 9

Phenomenological Equations and Transport properties, Rheological behavior of fluids, Models for Rheological Behavior; Balance Equations – Differential and Integral equations

UNIT II APPLICATIONS OF DIFFERENTIAL EQUATIONS OF CHANGE 9

Applications in laminar and turbulent transport in compressible and incompressible fluids, Boundary layer theory – Momentum, Thermal and Concentration Boundary layer, Similarity Transformation – Blasius Solution

UNIT III APPLICATIONS OF INTEGRAL EQUATIONS OF CHANGE 9

Reynolds Transport Theorem – application of RTT to solutions for Macroscopic balance for isothermal and non-isothermal systems and their applications in Momentum, Heat and Mass transport problems.

UNIT IV INTERPHASE AND MULTIPHASE MOMENTUM TRANSFER 9

Friction factor, Fluid systems, Flow patterns in vertical and horizontal pipes, Formulation of bubbles and drops and their size distribution, Solid fluid systems, Forces acting on stagnant and moving solids, Flow through porous medium, capillary tube model and its applications.

UNIT V INTERPHASE TRANSPORT IN NON-ISOTHERMAL SYSTEMS 9

Heat Transfer coefficient, Forced convection in tubes, around submerged objects, Heat Transfer by free convection, film type and dropwise condensation and equations for heat transfer, Heat transfer in boiling liquids, Mass Transfer co-efficient in single and multiple phases at low and high mass transfer rates, Film theory, Penetration theory, Boundary layer theory, Macroscopic balance to solve steady and Unsteady state problems.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

CO1: Recall Phenomenological Equations, Transport properties and rheological behavior of fluids.
CO2: Apply differential equation of change for momentum, heat and mass transport problems.
CO3: Apply integral equations of change for momentum, heat and mass transport problems.
CO4: Analyze interphase and multiphase momentum transfer
CO5: Evaluate interphase transport in non-isothermal system and to solve steady and Unsteady state problems.

REFERENCE BOOKS:

1. Bird, R. B., Lightfoot, E. N., & Stewart, E. W., "Transport phenomenon", Wiley, 2007.
2. Welty, J.R., Wicks, C. E. and Wilson, R. E., "Fundamentals of Momentum, Heat Mass Transfer", 5th Edn., John Wiley and Sons, 2007
3. Deen, W. M., "Analysis of Transport Phenomena", Topics in Chemical Engineering (Vol. Oxford University Press, New York. 1998.
4. Leal, L. G., "Advanced transport phenomena: fluid mechanics and convective transport processes", (Vol. 7). Cambridge University Press, 2007.
5. Brodkey, R. S., and Hershey, H. C., "Transport phenomena: a unified approach", Brodkey publishing, 2003.

Course Articulation Matrix:

Course Outcomes	**Program Outcomes**					
	PO 1	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**
CO1	3	1	3	3	2	1
CO2	3	1	3	3	2	1
CO3	3	1	3	3	2	1
CO4	3	1	3	3	2	1
CO5	3	1	3	3	2	1
Average CO	3	1	3	3	2	1

1, 2 and 3 are correlation levels with weightings as Slight (Low), Moderate (Medium) and Substantial (High) respectively

CL3102 ADVANCED REACTION ENGINEERING

L	T	P	C
3	0	0	3

OBJECTIVES:

- To make the students to Analyze the different types of models and kinetics of non-catalytic reaction.

- To enable the students to Determine the properties of catalyst and understand catalytic deactivation mechanism.
- To impart the students to Understand to write the kinetic expression for catalytic reactions.
- To enable the students to Understand the mass and heat transport process in catalyst.
- To make the students to Understand the modelling of the reactors.

UNIT I GAS SOLID NON-CATALYTIC REACTIONS AND REACTORS 9

Reaction kinetics, Different models used for gas solid non-catalytic reactions, shrinking core model, volume reaction model, zone models, grain models, rate controlling steps; time for Complete Conversion for Single and Mixed Sizes, design of gas solid reactors.

UNIT II GAS SOLID CATALYTIC REACTION 9

Steps in catalytic reaction, Single site, dual site mechanisms, Langmuir Hinshelwood, Eley Rideal, Rate controlling steps. Experimental methods for determining rate. Intra particle diffusion mechanism of catalytic reactions- under isothermal and non-isothermal condition.

UNIT III FLUID-FLUID REACTION 9

Kinetics and design of Fluid-Fluid Reactions. Rate equation, Kinetic regimes for absorption combined with chemical reaction. Various cases of mass transfer with chemical reaction, Factors to select the contactor, gas-liquid reactor design, liquid-liquid reactors and Design.

UNIT IV ADVANCED REACTOR SYSTEMS 9

Conventional reactors, advanced reactors– Static mixer reactor, Monolith Reactors, Spinning disc reactor, Multifunctional Reactors– Reactive distillation, Reactive extraction, Membrane reactor; Solar reactors, Micro channel reactors.

UNIT V MODELLING OF CHEMICAL REACTOR SYSTEMS 9

Steady state and unsteady state modelling concepts, Modelling batch reactors and tubular reactors systems, Reactor optimization.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

CO1: Analyze the various models and kinetics of non-catalytic reaction.
CO2: Evaluate the mechanism of catalytic reaction mechanism.
CO3: Apply the knowledge to evaluate the fluid- fluid reactor tower design
CO4: Distinguish different types of the advanced reactor systems
CO5: Develop different models for the chemical reactors

REFERENCE BOOKS:

1. Dorasiswamy, L.K., Deniz Uner, Chemical Reaction Engineering Beyond the fundamentals, First edition, CRC Press, 2014
2. Froment, G.F. and Bischoff, K.B., “Chemical Reactor Design and Analysis”, Third Edition, John Wiley &Sons, New York,2011.
3. S. Suresh S. Sundaramoorthy Green Chemical Engineering: An Introduction To Catalysis Kinetics And Chemical Processes, First edition CRC Press;,2014
4. Levenspiel, O. Chemical Reaction Engineering, Third Edition, JohnWiley1999
5. H.S.Fogler, Elements of Chemical Reaction Engineering, ThirdEdition,PrenticeHallofIndia,1999

Course Articulation Matrix:

Course Outcomes	Program Outcomes					
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6

CO1	3	2	2	1	2	2
CO2	3	2	2	1	2	-
CO3	3	2	2	1	2	--
CO4	3	2	-	1	2	--
CO5	3	2	2	1	2	-
Average CO	3	3	2	2	1	2

1, 2 and 3 are correlation levels with weightings as Slight (Low), Moderate (Medium) and Substantial (High) respectively

CL3103 ADVANCED PROCESS CONTROL

L	T	P	C
2	0	2	3

OBJECTIVES:

- To enable the students to learn fundamentals of linear time-varying systems and non-linear systems
- To make the students aware of different advanced control strategies for various industrial applications
- To impart students the knowledge on model-based control methods for linear and nonlinear systems
- To facilitate students the understanding on the dynamics of multivariable systems
- To educate the students on industrial implementation of digital control systems

UNIT I ADVANCED CONTROL STRATEGIES 6

Linear, nonlinear regression fitting for first order, second order models without and with time delay; development of discrete time model and parameter identification; Advanced control - Feed forward, cascade, dead time compensation, split range, inferential, selective and override control; smith predictor; automatic tuning and gain scheduling

UNIT II MODEL BASED CONTROL DESIGN 6

Model based control – IMC structure, development and design; Direct synthesis method; IMC based PID control, Overview of MPC - prediction for SISO and MIMO models, MPC calculation, set point calculation, selecting the tuning parameters in MPC, Design examples for typical case studies; Introduction to Non-linear MPC

UNIT III MULTIVARIABLE CONTROL 6

Control loop interaction – general pairing problem, relative gain array and application, sensitivity; Multivariable control – zeros and performance limitations, directional sensitivity and operability, decoupling

UNIT IV DISCRETE SYSTEMS & NON-LINEAR SYSTEMS 6

Z – Transform and inverse Z – transform properties; Discrete – Time Response of dynamic system, Pulse Transfer Function, Closed Loop System Stability; Models for Time-varying and Nonlinear systems; Hammerstein and Wiener Systems; Fuzzy logic controls; Neural network control

UNIT V DIGITAL FEEDBACK CONTROLLERS 6

Design of digital feedback controllers - Essential components, Digital control implementation, Programmable Logic Controller, Distributed Control System, SCADA, Hardware for computer - based control, Interfacing computer system with process

THEORY: 30 PERIODS

LIST OF EXPERIMENTS

Level control process with data acquisition
Temperature control process with data acquisition

Flow control process with data acquisition
Pressure process trainer with data acquisition
Implementation of Model Predictive Control in process control station
Implementation of Fuzzy logic, control in process control station
PLC and web based real time process control system
Integration of process control equipment in COMOS software
Create P & ID diagram
. Simulation of process plant using COMOS software

PRACTICAL: 30 PERIODS

COURSE OUTCOMES:

CO1: Identify and apply different advanced control configurations for specific applications
CO2: Compare and understand the capability of model-based control systems
CO3: Analyze the multivariable systems with interaction and its sensitivity
CO4: Gain fundamental knowledge on Z transform to analyze discrete systems
CO5: Gain exposure on the implementation of digital control systems
PRACTICAL
CO6: Implement PLC based control of a process
CO7: Implement Model Predictive control of a process
CO8: Implement PLC and webserver based real time process control

REFERENCE BOOKS:

1. Bequette, B. W., "Process Control: Modeling, Design, and Simulation", Prentice Hall, 2003
2. Stephanopoulos G., "Chemical Process Control", 1st ed., Pearson Education India, New Delhi, 2015.
3. Kannan M. Moudgalya, "Digital Process Control", John Wiley & Sons Ltd,2007
4. W L Luyben, "Process Modeling Simulation & Control for Chemical Engineers", McGraw Hill Education, 2nd edition, 2013
5. Seborg D.E., Edgar, T. F., Mellichamp D.A., "Process Dynamics and Control", 3rd ed., Wiley India, New Delhi, 2013.

Course Articulation Matrix

Course Outcomes	**Program Outcomes**					
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	2	1	1	3	2	1
CO2	1	1	3	3	1	1
CO3	2	2	3	3	3	1
CO4	2	1	3	3	2	1
CO5	3	2	3	3	3	2
CO6	3	2	3	3	3	2
CO7	3	2	3	3	3	2
CO8	3	2	3	3	3	2
Average CO	2.38	1.63	2.75	3	2.5	1.5

CL3104 **CHEMICAL PROCESS DESIGN** **L T P C**
3 0 0 3

OBJECTIVES:

- To enable the students to learn individual aspects of chemical plant design, optimization and
- To enable the students to understand the hierarchy of analysis and decisions in chemical process design
- To impart knowledge on the synthesis methods for chemical process and its alternatives
- To enable the students to integrate the unit processes and energy networks
- To impart knowledge on various process loops and optimization

UNIT I THE NATURE OF CHEMICAL PROCESS DESIGN AND INTEGRATION 9

Process design development; process comparison; formulation of design problem - the hierarchy and approaches of chemical process design, economics, health, safety hazards and integration.

UNIT II DESIGN OF REACTORS 9

Types of reaction systems; design of idealized reactors; reactor performance; reactor conditions and reactor configuration.

UNIT III DESIGN OF SEPARATION SYSTEM 9

Separation systems introduction - choice of separator for homogeneous fluid mixtures, choice of separator for heterogeneous fluid mixtures; distillation sequencing; adsorption - Pressure swing, thermal swing.

UNIT IV ENERGY INTEGRATION AND HEAT EXCHANGER NETWORK SYNTHESIS 9

Heat exchanger networks design; energy target – pinch technology; heat recovery systems - composite curves, problem table algorithm.

UNIT V RECYCLE SYSTEMS FOR CONTINUOUS AND BATCH PROCESS 9

Functions of process Recycles in continuous and batch processes; process Yield; optimization of recycle loop in continuous and batch process.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

CO1: Recognize various aspects of process design project objectives, approaches of process design.

CO2: Classify various choice of reactors and its performance assessment, reactor configuration

CO3: Formulate design of different types of separations process for homogeneous and heterogeneous mixtures.

CO4: Apply types of Heat exchanger networks for the target of energy and costs.

CO5: Analyze Recycle systems in order to optimize the process

REFERENCE BOOKS:

1. Smith, R., “Chemical Process: Design and Integration”, John Wiley and Sons, UK, 2005.
2. Peters, Max S., Timmerhaus K.D., and West R.E., “Plant Design and Economics for Chemical Engineers”, 5^{th} Ed., McGraw-Hill International Editions (Chemical Engineering Series), New York, 2003.
3. Silla.H., “Chemical Process Engineering(Design and Economics)”, Taylor and Francis Group LLC,USA, 2003.
4. Douglas, James M., “Conceptual Design of Chemical Processes”, McGraw-Hill International Editions (Chemical Engineering Series), New York, 1988.

5. Robert E. Treybal, “Mass Transfer Operations”, 3rd Ed., McGraw-Hill International Editions, Singapore, 1981.
6. Xian Wen Ng, “Concise Guide to Heat Exchanger Network Design”, Springer Nature Switzerland AG, 2021.
7. Xing Luo, Wilfried Roetzel, Dezhen Chen, “Design and Operation of Heat Exchangers and their Networks”, 1st Ed. Academic Press. 2019.

Course Articulation Matrix:

Course Outcomes	**Program Outcomes**					
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	3	3	1	3	2	3
CO2	3	3	1	3	3	3
CO3	3	3	1	3	3	3
CO4	3	3	1	3	3	3
CO5	3	3	3	3	3	3
Average CO	3	3	1.4	3	2.8	3

1, 2 and 3 are correlation levels with weightings as Slight (Low), Moderate (Medium) and Substantial (High) respectively

CL3201 SEPARATION PROCESSES **L T P C**
2 0 2 3

OBJECTIVES:

- To impart knowledge on recently developed unit operations like membrane separation, adsorption, Chromatography, supercritical fluid extraction and advanced distillation techniques.
- To acquaint the students with various types of contacting systems viz. liquid-liquid, solid-liquid, gas-solid with their technical insights.
- To impart knowledge on theoretical and practical insight of advanced separation techniques.
- To make the students understand the utilization of soft wares for the design of membrane and distillation units.
- To enable the students to select appropriate separation methodology for an intended application.

UNIT I MEMBRANE SEPARATION PROCESSES 6

Membrane types, materials, synthesis and characterization; Different membrane modules; Working principle, operating parameters, membranes used, transport processes/mechanisms and industrial applications for individual membrane processes such as Reverse osmosis, nanofiltration, ultrafiltration, microfiltration; MBR; Reverse Osmosis process design using software

UNIT II ADSORPTION AND ION EXCHANGE 6

Fundamentals and types of adsorption, Types and properties of adsorbents, Adsorption Equilibrium and isotherms, stage contact operations, Fixed bed adsorption; Ion Exchange - Fundamentals of Ion Exchange Types of Ion Exchange Resins Theory of Ion Exchange, Applications - Removal and recovery of heavy metals, Removal of nitrogen, Removal of phosphorus, Organic chemical removal

UNIT III CHROMATOGRAPHIC SEPARATION 6

Principle and operation, Types of chromatography - Ion exchange chromatography, Gel filtration and affinity chromatography, Thin layer and paper chromatography, Liquid chromatography, Simulated Moving bed chromatography, Multicomponent Differential Chromatography; Advantages and disadvantages of chromatographic separations.

UNIT IV SUPERCRITICAL EXTRACTION 6

Working Principal, unique properties and solubility behavior of supercritical fluids, Advantages of supercritical extraction, Decaffeination, ROSE process for purification of crude oil, hydrothermal oxidation, and Commercial applications of supercritical extraction

UNIT V ADVANCED DISTILLATION TECHNIQUES 6

Reactive and catalytic distillation Concept, advantage & disadvantages, Structured packing and its comparison with conventional techniques, Concept & working of short path Distillation Unit (SPDU)

THEORY: 30 PERIODS

LIST OF EXPERIMENTS PRACTICAL: 30 PERIODS

1. Determination of the water permeability of a given polymeric membrane.
2. Determination of permeation flux of a membrane in flat-sheet module (Dye-water solution may be used as feed) (RO/NF/UF membranes can be used)
3. Numerical/design of reverse osmosis process using software.
4. Waste Water Treatment using MBR.
5. Adsorption Equilibrium and fixed bed adsorption studies for generation of breakthrough curves
6. Determination of ion exchange capacity of a given cation or anion exchanger
7. To separate a mixture of dyes using chromatography
8. Experimental design in supercritical fluid extraction
9. Study of extraction efficiency for the extraction of essential oils
10. Numerical/design assignment based on reactive and catalytic distillation.

TOTAL: 60 PERIODS

COURSE OUTCOMES:

CO1: Design and develop membrane system for the determination of flux.

CO2: Discuss fixed bed column (Adsorption / Ion Exchange) for the separation of component from the system of fluids.

CO3: Apply chromatographic techniques.

CO4: Interpret simple phase diagrams and judge their implication in the design of a supercritical fluid process.

CO5: Assess and optimize advanced distillation techniques.

Practical

CO6: Recall and apply foundational concepts in real membrane system

CO7: Demonstrate column studies for the separation of components

CO8: Optimize the results

REFERENCE BOOKS:

1. J.D. Seader and E.J. Henley, "Separation Process Principles", John Wiley & Sons, 1998.
2. B. K. Dutta, "Principles of Mass Transfer and Separation Processes", Prentice Hall India Learning Private Limited, 2006.
3. Baker, R. W., "Membrane technology and applications", John Wiley & Sons, 2012.
4. C.J. Geankoplis, "Transport Processes and Separation Process Principles", Prentice Hall India Learning Private Limited, 2004.
5. Wankat, P. C., "Separation process engineering", Pearson Education, 2006.

Course Articulation Matrix:

Course Outcomes	Program Outcomes					
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	3	3	3	3	3	3
CO2	3	3	3	3	3	3
CO3	3	3	3	3	3	3
CO4	3	3	3	3	3	3
CO5	3	3	3	3	3	3
CO6	3	2	3	3	3	3
CO7	2	2	1	2	2	3
CO8	1	2	1	2	2	3
Average CO	2	1.5	1.63	1.88	1.5	2.13

1, 2 and 3 are correlation levels with weightings as Slight (Low), Moderate (Medium) and Substantial (High) respectively

CL3202 SOFTWARE APPLICATIONS IN CHEMICAL INDUSTRIES L T P C
2 0 2 3

OBJECTIVES:

- To enable the students to learn about python language with its application.
- To impart knowledge about Microsoft-excel for solving various chemical engineering
- To enable the students to learn about the role of MATLAB in various chemical industries and its applications
- To impart knowledge on ASPEN and its application in various chemical industries
- To enable the students to learn about HYSYS and its application in chemical and petroleum refining industries

UNIT I PYTHON FOR PROCESS ENGINEERS 6

Introduction – variable and identifiers; Arithmetic operators – conditionals – If else loop, while loop, for loop – function cell ; simple data structure in python – strings, dictionaries & modules ; File handling. Exercises can be generalized.

UNIT II MICROSOFT EXCEL FOR CHEMICAL THERMODYNAMICS 6

Application in Density, molecular weight, mole and percentage compositions; Empirical and Molecular formula calculations, Heat of mixing, Gas laws, Vapor pressure, and Chemical Kinetics calculations; Application in data processing- Statistical analysis of data and Regression. Analysis of variance, Interpolation, and Graphical representations of various Chemical Engineering problems; Interfacing with different soft-wares for data transfer and job applications Exercises can be generalized.

UNIT III MATLAB FOR NUMERICAL APPLICATIONS 6

Introduction to MATLAB, workspace environment, variable and data entry, matrix operations; MATLAB functions, Programming in MATLAB to solve Chemical engineering problems; Introduction to Simulink Exercises can be generalized.

UNIT IV ASPEN FOR PROCESS INDUSTRIES 6

Introduction to ASPEN, application of ASPEN in chemical engineering problems; simulation of Individual process equipment and flow sheet using Aspen Plus, property analysis and estimation using Aspen Properties Exercise can be generalized.

UNIT V HYSYS FOR SIMULATION IN PROCESS INDUSTRIES 6

Introduction to HYSYS, process modelling and simulation using HYSYS, design performance monitoring using HYSYS, application of HYSYS in petroleum industries, case studies, Chemical Engineering Problems using HYSYS. Exercise can be generalized.

THEORY: 30 PERIODS

LIST OF EXPERIMENT **PRACTICAL: 30 PERIODS**

1. Write a python program for temperature conversion from ^{o}C To ^{o}F
2. Write a python program to determine the excess oxygen supplied for combustion
3. Determine the molar volume and compressibility factor using Goal Seak
4. Determine the three-phase bubble point using Solver
5. Determine the terminal velocity using Goal Seek
6. Write a MATLAB program to calculate the vapor pressure of water according to Antoine equation: logP=(A-B/(T+C))
   Where T is any given temperature in Kelvin and A, B, and C are Antoine coefficients: A=18.3036,B=3816.44,C= -46.13.
7. Write a MATLAB program to solve this problem using Runge-Kutta 4 order equation
8. Problem: Distillation: A mixture containing 50.0 wt% acetone and 50.0 wt% water is to be separated into two streams – one enriched in acetone and the other in water. The separation process consists of extraction of the acetone from the water into methyl isobutyl ketone (MIBK), which dissolves acetone but is nearly immiscible with water. The overall goal of this problem is to separate the feed stream into two streams which have greater than 90% purity of water and acetone respectively.
9. Problem: Flash separation: A stream containing 15% ethane, 20% propane, 60% i-butane and 5% n-butane at 50°F and atmospheric pressure, and a flow rate of 100 lbmole/hr. This stream is to be compressed to 50 psia, and then cooled to 32°F. The resulting vapor and liquid are to be separated as the two product streams. What are the flow rates and compositions of these two streams?

TOTAL: 60 PERIODS

COURSE OUTCOMES:

CO1: Recognize the various software's used in chemical engineering industries and learn about C and C++ language with its application

CO2: Solve various chemical engineering problems using Microsoft excel

CO3: Demonstrate the role of MATLAB in various chemical industries and its applications

CO4: Apply basic knowledge about ASPEN and its application in various chemical industries

CO5: Evaluate HYSYS and its application in chemical and petroleum refining industries

PRACTICAL

CO6: Analyze chemical engineering problems using python programing and Microsoft excel

CO7 Using MATLAB and Aspen solve problems based on material balance without reaction, with reaction and energy balance

CO8 Solve process industry-oriented problems using HYSYS

REFERENCE BOOKS:

1. Hanna, O.T. Scandell, O.C. Computational Methods in Chemical Engineering, Prentice Hall, 1995.
2. R.K. Taxali, T.K. dBase IV made simple, Tata McGraw-Hill 1991. 80
3. Finlayson, B. A., Introduction to Chemical Engineering Computing, John Wiley & Sons, New Jersey, 2006.
4. Jerry, O., Breneman, G.L. Spreadsheet Chemistry, Prentice Hall, Englewood Cliffs, 1991.
5. Myers, A.L. Seider W.D. Introduction to Chemical engineering and Computer Calculations.
6. Reema Thareja, Python programming using problem solving approach, oxford university press, 2017.
7. Allen B. Downey, Think Python: How to think like a computer scientist, second edition, shroff/O'Reilly Publishers, 2016.

Course Articulation Matrix:

Course Outcomes	Program Outcomes					
	PO1	PO2	PO3	PO4	PO5	PO6
CO1	1	1	2	3	2	-
CO2	2	2	3	3	3	-
CO3	2	3	3	3	3	-
CO4	2	3	3	3	3	-
CO5	2	3	3	3	3	-
CO6	2	3	3	3	3	-
CO7	2	3	3	3	3	-
CO8	2	3	3	3	3	-
Average CO	1.8	2.4	2.8	3	2.8	-

1, 2 and 3 are correlation levels with weightings as Slight (Low), Moderate (Medium) and Substantial (High) respectively

CL3203 ADVANCED THERMODYNAMICS FOR CHEMICAL ENGINEERS **L T P C**
3 0 0 3

OBJECTIVES:

- To impart knowledge on the basics of laws of energy relations and partial derivatives for PVT relations
- To enable the students to understand the thermodynamics of phase equilibria typically present in design of chemical processes, in particular, in separation operations
- To impart the students to learn about advance Phase and chemical equilibria of multi-component systems
- To enable the students to learn about molecular thermodynamics to understand the multi-component interactions
- To make the students to relate thermodynamic concepts to separation applications, specifically related to petroleum and chemical process industries.

UNIT I OVERVIEW OF THERMODYNAMICS 9

Thermodynamic Energy Law; Reversibility and second Law; Review of Basic Postulates, equation of state and its applications, corresponding states, equilibrium criteria, Entropy calculations ,Legendre Transformation and Maxwell's relations.

UNIT II FLUID PHASE EQUILIBRIA 9

Phase rule, Stability of thermodynamic systems, first order phase transitions and critical phenomenon, single component phase diagrams, thermodynamic properties of single phase and multicomponent system.

UNIT III SOLUTION THERMODYNAMICS 9

Partial molar properties, Gibbs-Duhem equation, fugacities in gas and liquid mixtures, activity coefficients, Ideal and Non-ideal solutions, azeotropes, Excess Functions; Calculation of vapor liquid equilibria using equations of state; Classical and excess free energy based mixing rules,Wilson, NRTL, and UNIQUAC equations, UNIFAC method.

UNIT IV VAPOR LIQUID EQUILIBRIA 9

Vapour Liquid Equilibrium involving low pressure, high pressures and multi component systems, VLE in ideal and non- ideal solutions, Solid-Liquid Equilibria (SLE); Vapor-Liquid Liquid Equilibria(VLLE);Phase Equilibria of Solid-Solid Mixtures. Applications - Phase equilibria in polymer solutions, Electrolytes

UNIT V REACTION EQUILIBRIA 9

Criteria of chemical reaction equilibrium in thermodynamic systems, Homogeneous gas and liquid phase reactions, heterogeneous reactions – phase and chemical equilibrium , Introduction to molecular thermodynamics, Intermolecular forces, Potential function

TOTAL: 45 PERIODS

COURSE OUTCOMES:

CO1: Recall the basic concepts of energy and laws of thermodynamics to applications that require quantitative knowledge of thermodynamic properties at macroscopic level.

CO2: Review the thermodynamics of phase equilibria for the design of chemical processes

CO3: Analyze the fundamental property relation and derivative relations and compute the VLE using excess energy models

CO4: Apply the solution methods for vapor -liquid equilibrium and understand the LLE and VLLE phase behavior, including the ability to identify the onset of liquid instability

CO5: Assess the influences of pressure, nonstoichiometric feed and inerts on reaction equilibrium and the Gibbs minimization method for calculating reaction equilibrium.

REFERENCE BOOKS:

1. J. Richard Elliott, Carl T. Lira, a Introductory Chemical Engineering Thermodynamics, 2nd Edition", 2nd edition, Prentice Hall, 2012
2. J.M.Smith, H.C.Van Ness, Michael M. Abbott, Introduction to Engineering Thermodynamics, McGraw Hill, New York, 2005.
3. M.D. Koretsky, Engineering and Chemical Thermodynamics, 2nd edition, Wiley; 2nd edition, 2012
4. Prauznitz, J.M., R.N. Lichtenthaler, E.G. de Azevedo, "Molecular Thermodynamics of Fluid Phase Equilibria", 3rd ed., Prentice Hall, 1999
5. S.M. Walas, Phase Equilibria in Chemical Engineering•, Butterworths, 1985.
6. Y.V.C.Rao, Chemical Engineering Thermodynamics, 2003

Course Articulation Matrix:

Course Outcomes	Program Outcomes					
	PO 1	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**
CO1	3	3	3	3	3	1
CO2	3	3	3	3	3	1
CO3	3	3	3	3	3	2
CO4	2	3	3	3	3	2
CO5	3	3	3	3	3	2
Average CO	2.8	3	3	3	3	1.6

1, 2 and 3 are correlation levels with weightings as Slight (Low), Moderate (Medium) and Substantial (High) respectively

CL3204	**CHEMICAL PROCESS OPTIMIZATION**	**L**	**T**	**P**	**C**
		3	**0**	**0**	**3**

OBJECTIVES:

- To enable the students to learn basics of Optimization.
- To enable the students to learn Formulation of an optimization problem
- To impart knowledge on finding solutions for nonlinear unconstrained optimization.

- To enable the students to understand the role of constraints on the solution of an optimization problem
- To make the students to explore the optimal and dynamic optimization techniques.

UNIT I INTRODUCTION 9

Introduction to optimization; applications of optimization in chemical engineering; classification of optimization problems; Problem formulation, degree of freedom analysis, objectives functions, constraints and feasible region, general procedure for solving optimization problems, Types of optimization problem, obstacles to optimization.

UNIT II LINEAR PROGRAMMING 9

Introduction to Linear Programming (LP). Graphical representation. Basic assumptions. Simplex method, Barrier method, sensitivity analysis, Examples.

UNIT III NONLINEAR UNCONSTRAINED OPTIMIZATION 9

Convex and concave functions unconstrained NLP, Newton's method Quasi-Newton's method, Examples.

UNIT IV CONSTRAINED OPTIMIZATION 9

Direct substitution, Quadratic programming, Penalty Barrier Augmented Lagrangian Methods.

UNIT V MULTI OBJECTIVES OPTIMIZATION 9

Weighted Sum of Squares method, Epsilon constrain method, Goal attainment, Examples. Introduction to optimal control and dynamic optimization.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

CO1: Describe the basics problem formulation and optimization.
CO2: Discuss mathematical characteristics of linear programming.
CO3: Explain computational solution techniques for nonlinear unconstrained optimization.
CO4: Demonstrate various techniques used in constrained optimization
CO5: Apply the optimal and dynamic optimization.

REFERENCE BOOKS:

1. Edgar, T. F., Himmelblau, D. M. and Ladson, L. S., "Optimization of Chemical Processes",2nd Ed., McGraw Hill, New York, 2003.
2. Rao, S. S., Engineering Optimization: Theory and Practice, New Age Publishers, 2000
3. Diwaker, U. W. "Introduction to Applied Optimization", Kluwer, 2003.
4. Joshi, M. C. and Moudgalya, K. M., "Optimization, Theory and Practice", Narosa, New Delhi, 2004.

Course Articulation Matrix:

Course Outcomes	Program Outcomes					
	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	1	2	3	3	2
CO2	3	1	2	3	3	-
CO3	3	1	2	3	3	2
CO4	3	1	2	3	3	1
CO5	3	1	2	3	3	1
Average CO	3	1	2	3	3	1.2

1, 2 and 3 are correlation levels with weightings as Slight (Low), Moderate (Medium) and Substantial (High) respectively

CL3211 MINI PROJECT WITH SEMINAR

L	T	P	C
0	0	2	1

OBJECTIVES:

- To enable students to get exposed to the recent developments, and to improve the student's presentation skills.
- To make the students conduct literature review and to demonstrate the studies
- To enable the students to improve on writing and presentation skills

COURSE CONTENT

- The students will be exposed to training in preparation and presentation skills.
- They will be involved in searching latest research in the area of chemical engineering
- Skill development on Report and Thesis writing

COURSE OUTCOMES

CO1: Gain knowledge on practical based work and use it to computational methods
CO2: Analyze data on CFD and other software's
CO3: Analyze the lab data and interpret with real time problems to bring solutions

Course Articulation Matrix:

Course Outcomes	Program Outcomes					
	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	3	2	3	3	1
CO2	2	2	3	3	2	2
CO3	3	2	3	3	1	2
Average CO	3	3	3	3	2	1

1, 2 and 3 are correlation levels with weightings as Slight (Low), Moderate (Medium) and Substantial (High) respectively

SEMESTER III

CL3301 MODELING OF CHEMICAL PROCESSES

L	T	P	C
3	1	0	4

OBJECTIVES:

- To enable students to develop steady state and transient models for processes and unit operations
- To impart knowledge on lumped and distributed parameter models and to seek solution of models using analytic and numerical techniques
- To enable students to construct data driven models and estimate the parameters
- To make the students learn computational techniques to solve the process models
- To enable students to use simulation tools such as MATLAB/SCILAB

UNIT I OVERVIEW 12

Need for developing models for a process - Incentives of process modeling and simulation - classification of mathematical models, conservation equations and auxiliary relations - Closed form of solution – Well posedness of Models, Degree of freedom analysis - Design and Control degrees of Freedom - Degrees of Freedom Analysis for flowsheets involving single and multiple process units – Flowsheeting, Intoduction to Black box, White Box and Grey Box Modelling, Artificial Neural Networks – ANN Applications.

UNIT II ALGEBRAIC MODELS 12

Models yielding linear and non-linear algebraic equations - Solution to linear and non-linear algebraic equations - Convergence - Types of Convergence - Wegstein's Algorithm - Levenberg-Marquadt Method, Application of algebraic models to dimensional analysis and determination of independent species in a set of reactions.

UNIT III MODELS YIELDING ODE 12

Models yielding ODE - Classification of ODE - Solution of ODE - analytical methods using matrices and numerical methods, Runge- Kutta methods of various orders, Mathematical models with Initial and or Boundary conditions of surge tank, Transient isothermal and non-isothermal Mixed flow reactor, separation systems such as distillation, flashing, Coiled and Jacketed heaters.

UNIT IV MODELS YIELDING PDE 12

Models yielding PDE's - Characteristics and differences between Lumped and Distributed Parameter systems - classification and solution of partial differential equations – Characteristic curves for parabolic, Elliptic and Hyperbolic equations - Mathematical models of Heat Exchanger, Packed bed reactor, plug flow reactor, Convection-Diffusion-Reaction (CDR) model, packed bed adsorption, Solution of ODE boundary value problems – Finite difference, Finite Element and Finite volume methods.

UNIT V OTHER MODELS AND SOFTWARES 12

Empirical modeling, parameter estimation, principle of linear and non-linear least squares - Population balance and stochastic modeling- Application of population balance models in crystallization, particle comminution, RTD in reactors - Principal Component Analysis - Kernel PCA - Singular Value Decomposition. Solve the problems using MATLAB/SCILAB and ASPEN Plus in association with any programming language, Machine learning or Deep Learning Model Development.

TOTAL: 60 PERIODS

COURSE OUTCOMES:

CO1 Understand the fundamentals of modeling and their applications to transport/energy equations, chemical and phase equilibria kinetics.

CO2 Construct mathematical models for different unit operations equipments such as stirred tank heaters, Heat exchangers, Evaporators, Reactors, distillation columns.
CO3 Analyze the principles of steady state/unsteady state lumped systems and steady state/ unsteady state distributed systems.
CO4 Apply relevant solution methods for the mathematical models with relevant initial and/or boundary conditions both the manually and using software.
CO5 Evaluate the applicability of stochastic, population balance model and data driven models.

REFERENCE BOOKS:

1. Bequette, B.W., “Process Dynamics: Modelling, Analysis and Simulation,” Prentice Hall (1998).
2. Himmelblau D.M. and Bischoff K.B., Process Analysis and Simulation, Wiley, 1988.
3. Varma A. and Morbidelli M., Mathematical Methods in Chemical Engineering, Oxford University Press, 1997.
4. Gilbert Strang, “Linear Algebra and its Applications”, Wellesley, MA : Wellesley-Cambridge Press, Fourth Edition, 2009.
5. Ogunnaike B. and W. Harmon Ray, Process Dynamics, Modeling, and Control, Oxford University Press, 1995.
6. Chapra S.C. and Canale R.P. Numerical Methods for Engineers, McGraw Hill, 2001.
7. Ramirez, W.; “ Computational Methods in Process Simulation “, 2nd Edn., Butterworths Publishers, New York, 2000.

Course Articulation Matrix:

Course Outcomes	Program Outcomes					
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	3	2	3	3	2	1
CO2	3	2	3	3	2	1
CO3	3	2	3	3	2	1
CO4	3	2	3	3	2	1
CO5	3	2	3	3	2	1
Average CO	3	2	3	3	2	1

1, 2 and 3 are correlation levels with weightings as Slight (Low), Moderate (Medium) and Substantial (High) respectively

CL3311 PROJECT WORK I L T P C
0 0 12 6

OBJECTIVES:

The course aims to enable the students to identify the research problem relevant to their field of interest, search databases to define the problem, design experiment, conduct preliminary study and report the findings.

COURSE CONTENT

Individual students will identify a research problem relevant to his/her field of study with the approval of project review committee. The student will collect, and analyze the literature and design the experiment. The student will carry out preliminary study, collect data, interpret the result, prepare the project report and present before the committee.

TOTAL: 180 PERIODS

OUTCOMES:

At the end of the course the students will be able to

CO1: Identify the research problem
CO2: Collect, analyze the relevant literature and finalize the research problem
CO3: Design the experiment, conduct preliminary experiment, analyse the data and conclude
CO4: Prepare project report and present

Course Articulation Matrix:

Course Outcomes	Program Outcomes					
	PO 1	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**
CO1	3	2	2	1	1	2
CO2	3	3	2	2	2	2
CO3	3	2	2	3	2	2
CO3	2	3	3	1	2	2
Average CO	2.75	2.5	2.25	1.75	1.75	2

1, 2 and 3 are correlation levels with weightings as Slight (Low), Moderate (Medium) and Substantial (High) respectively

CL3411 PROJECT WORK II

L	T	P	C
0	0	24	12

I. Continuation of Project Work I (at Institution/Industry)

OBJECTIVES:
The course aims to enable the students to conduct experiment as per the plan submitted in Project work I to find solution for the research problem identified.

COURSE CONTENT
The student shall continue Project work I as per the formulated methodology and findings of preliminary study. The student shall conduct experiment, collect data, interpret the result and provide solution for the identified research problem. The student shall prepare the project report and present before the committee.

TOTAL: 360 PERIODS

OUTCOMES:
At the end of the course the students will be able to
CO1: Conduct the experiment and collect data
CO2: Analyze the data, interpret the results and conclude
CO3: Prepare project report and present

Course articulation Matrix

Course Outcomes	Program Outcomes					
	PO 1	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**
CO1	3	2	2	1	1	2
CO2	3	3	2	2	2	2
CO3	3	2	2	3	2	2
Average CO	3	2.33	2	2	1.67	2

II. Not the continuation of Project Work I (at Industry)

OBJECTIVES:
The course aims to enable the students to identify the research problem at the company, search databases to define the problem, design experiment, and conduct experiment to find the solution.

COURSE CONTENT
Individual students will identify a research problem relevant to his/her field of study at the company and get approval of project review committee. The student will collect, and analyze the literature and design the experiment. The student will carry out the experiment, collect data, interpret the result, prepare the project report and present before the committee.

TOTAL: 360 PERIODS

OUTCOMES:
At the end of the course the students will be able to
CO1: Identify the research problem
CO2: Collect, analyze the relevant literature and finalize the research problem
CO3: Design and conduct the experiment, analyse the data and conclude
CO4: Prepare project report and present

Course Articulation Matrix:

Course Outcomes	Program Outcomes					
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO1	3	2	2	1	1	2
CO2	3	3	2	2	2	2
CO3	3	2	2	3	2	2
CO4	2	3	3	1	2	2
Average CO	2.75	2.5	2.25	1.75	1.75	2

1, 2 and 3 are correlation levels with weightings as Slight (Low), Moderate (Medium) and Substantial (High) respectively

CL3001 BIOCHEMICAL ENGINEERING **L T P C 3 0 0 3**

OBJECTIVES:
- To impart knowledge on the role of enzymes and microbes in biotechnology sectors.
- To enable students to understand the design parameters in designing biochemical reactors.
- To impart knowledge on finding solutions to the problems with biomaterials and processes
- To impart knowledge in bioreactors
- To enable students to study economy of bio based industries.

UNIT I ENZYME CATALYSIS 9
Overview of biotechnology, Principles of Enzyme catalysis, Enzyme inhibition, Immobilized enzyme kinetics, internal mass transfer effects in immobilized enzyme kinetics.

UNIT II MICROBIAL GROWTH 9

Stoichiometry and energetics of microbial growth, Metabolic pathways and energetics of the cell, concept of energy coupling, ATP and NAD, Unstructured models of microbial growth, Structured models of microbial growth.

UNIT III BIOREACTOR DESIGN AND ANALYSIS 9

Bioreactors: CSTR, Plug flow and packed bed bioreactors, Fed batch reactors, Mass balances for two phase reactors, Power requirements, sterilization.

UNIT IV PRODUCT RECOVERY 9

Bioproduct recovery- Centrifugation, Filtration, Ultra filtration, Precipitation of Protein, Chromatography, Fixed bed adsorption, Phase theory of chromatography, Electrophoresis, Crystallization.

UNIT V BIOPRODUCTS AND ECONOMICS 9

Manufacturing of biological products, cost analysis of bioprocesses, case studies.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

CO1: Develop the ability to design novel bioprocesses for their research.
CO2: Classify engineering aspects of biological systems
CO3: Develop solutions to the problems with biomaterials and processes
CO4: Apply knowledge in bioreactors
CO5: Analyze economy of bio based industries.

REFERENCE BOOKS:

1. Shuler M.L. and Kargi F. Bioprocess Engineering: Basic Concepts, 1st Edition, Prentice Hall, New Jersey, 1992.
2. Lee J., Biochemical Engineering, Prentice Hall Englewood Cliffs, 1992.
3. Blanch H.W and Clark D.S, Biochemical Engineering, Marcel Dekker 1997.
5. James M.Lee , Biochemical engineering – Prentice-Hall-1992.
4. Shigeo Katoh, Jun-ichi Horiuchi and Fumitake Yoshida, “Biochemical Engineering”, Wiley, 2015.
5. Pauline M. Doran, Bioprocess engineering principles, Academic Press.
6. H.W. Blanch and D.S. Clark, Marcel Dekker, Biochemical Engineering, 1997

Course Articulation Matrix:

Course Outcomes	Program Outcomes					
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	1	2	1	-	-	1
CO2	1	1	2	-	2	3
CO3	1	2	2	-	2	3
CO4	1	3	3	1	2	1
CO5	1	2	3	1	2	3
Average CO	1	2	3	2	1	2

1, 2 and 3 are correlation levels with weightings as Slight (Low), Moderate (Medium) and Substantial (High) respectively

CL3002 WASTE TO ENERGY

L	T	P	C
3	0	0	3

OBJECTIVES:

- To enable the students to interpret the various types of wastes from which energy can be generated
- To impart knowledge on biomass pyrolysis process and its applications
- To impart knowledge on various types of biomass gasifiers and their operations
- To impart knowledge on biomass combustors and its applications on generating energy
- To enable the students to summarize the principles of bio-energy systems and their features

UNIT I INTRODUCTION TO EXTRACTION OF ENERGY FROM WASTE 9

Classification of waste as fuel – Agro based, Forest residue, Industrial waste - MSW – Conversion devices – Incinerators, gasifiers, digestors.

UNIT II PYROLYSIS 9

Pyrolysis – Types, slow fast – Manufacture of charcoal – Methods - Yields and application – Manufacture of pyrolytic oils and gases, yields and applications.

UNIT III GASIFICATION 9

Gasifiers – Fixed bed system – Downdraft and updraft gasifiers – Fluidized bed gasifiers – Design, construction and operation – Gasifier burner arrangement for thermal heating – Gasifier engine arrangement and electrical power – Equilibrium and kinetic consideration in gasifier operation.

UNIT IV COMBUSTION 9

Biomass stoves – Improved chullahs, types, some exotic designs, Fixed bed combustors, Types, inclined grate combustors, Fluidized bed combustors, Design, construction and operation - Operation of all the above biomass combustors.

UNIT V BIO ENERGY 9

Properties of biogas (Calorific value and composition), Biogas plant technology and status - Bio energy system - Design and constructional features - Biomass resources and their classification - Biomass conversion processes - Thermo chemical conversion - Direct combustion - biomass gasification - pyrolysis and liquefaction - biochemical conversion - anaerobic digestion - Types of biogas Plants – Applications - Alcohol production from biomass - Bio diesel production -Urban waste to energy conversion - Biomass energy programme in India.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

CO1: Identify various types of wastes from which energy can be generated
CO2: Describe biomass pyrolysis process and its applications
CO3: Appraise various types of biomass gasifiers and their operations
CO4: Evaluate biomass combustors and its applications on generating energy
CO5: Assess the principles of bio-energy systems and their features

REFERENCE BOOKS:

1. Biogas Technology - A Practical Hand Book - Khandelwal, K. C. and Mahdi, S. S., Vol. I & II, Tata McGraw Hill Publishing Co. Ltd., 1983.
2. Biomass Conversion and Technology, C. Y. WereKo-Brobby and E. B. Hagan, John Wiley & Sons, 1996.
3. Food, Feed and Fuel from Biomass, Challal, D. S., IBH Publishing Co. Pvt. Ltd., 1991.
4. Non Conventional Energy, Desai, Ashok V., Wiley Eastern Ltd., 1990.

Course Articulation Matrix:

Course Outcomes	Program Outcomes					
	PO1	PO2	PO3	PO4	PO5	PO6
CO1	-	-	2	-	-	-
CO2	-	-	2	-	-	-
CO3	-	-	2	1	-	-
CO4	2	-	2	2	-	-
CO5	-	-	2	-	-	-
Average CO	2	-	2	1.5	-	-

1, 2 and 3 are correlation levels with weightings as Slight (Low), Moderate (Medium) and Substantial (High) respectively

CL3003 MEMBRANE SEPARATION PROCESSES

L	T	P	C
3	0	0	3

OBJECTIVES:

- To impart the students an insight to the membrane-based separations and development of membranes modules
- To impart knowledge on Reverse Osmosis, Nanofiltration and Ultrafiltration
- To make the students understand about the principles of microfiltration and design of membrane systems
- To enable the students to learn about problems encountered and solutions to membrane processes.
- To make the students aware of other membrane separation processes.

UNIT I INTRODUCTION TO MEMBRANE SEPARATION PROCESS 9

Fundamentals of Membrane process, Membrane Materials, Types and preparation, Membrane characterization, Membrane modules, Mechanism of Transport through porous and nonporous membranes, Flow Pattern in membrane modules, Derivation of basic models for fluid permeation by membranes

UNIT II REVERSE OSMOSIS, NANOFILTRATION AND ULTRAFILTRATION 9

Reverse Osmosis - The phenomenon of reverse osmosis, Thermodynamic consideration, Solution diffusion model, Design and operating parameters; Nanofiltration - Principles of nanofiltration, Transport mechanism in nanofiltration, Design, operating parameters and process limitations; Ultrafiltration - Principle, Design parameters, Flux equation, Models for solvent flux, Problems and solutions based on RO, NF and UF

UNIT III MICROFILTRATION AND DESIGN OF MEMBRANE SYSTEMS 9

Microfiltration - Modes of flow in microfiltration membranes, Membrane configuration, mechanism of transport, Models for microfiltration, Membrane Module/Element designs: Membrane System components, Design of Membrane systems, pump types and Pump selection, Plant operations, Energy requirements in membrane separation process, Economics of Membrane systems, Case Studies

UNIT IV MEMBRANE FOULING AND CONTROL 9

Membrane Fouling, Types of fouling, Factors responsible and Mechanism involved in fouling, Theoretical models for membrane fouling, Pretreatment methods and strategies, monitoring of Pretreatment – Langlier Index, Silt Density Index, Impact of membrane material on fouling, Prevention of fouling, Methods to reduce concentration polarization, Fouling agents and their control measures, Cleaning techniques and optimization

UNIT V MEMBRANE BIOREACTORS AND OTHER MEMBRANE PROCESSESS 9

Historical Perspective of MBRs, MBR Configurations, Fouling and Fouling Control, Pervaporation concepts and mass transfer in pervaporation, Liquid Membranes, types and mechanism of transport, Gas separation, Membrane Distillation, Problems and solutions based on PV, LM, GS and MD, Case studies.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

CO1: Recall the basic principle, different types of membrane and membrane modules.

CO2: Recognize the various membrane process such as reverse osmosis, nanofiltration and ultrafiltration

CO3: Illustrate the concepts of microfiltration and to develop necessary skills to design appropriate membrane-based separation technique as per the need.

CO4: Review Fouling, Scaling, Concentration Polarization, and solutions

CO5: Evaluate the configuration of MBR and scope of Membrane technology.

REFERENCE BOOKS:

1. Mulder, M., "Basic Principle of Membrane Technology", Kluwer Academic Publishers, 1996.
2. Noble, R.D. and Stern, S.A., "Membrane Separations Technology: Principles and Applications", Elsevier, 1995.
3. Judd S., B.Jafferman, "Membranes for Industrial Waste Water Recovery and Re-use", Elsevier Publications, 2003.
4. M. C. Porter, "Handbook of industrial membrane technology", Noyes publication, Park Ridge, New Jersey, 1990.
5. Symon Jud, "MBR Book – Principles and application of MBR in water and wastewater treatment", Elservier, 2006.

Course Articulation Matrix:

Course Outcomes	Program Outcomes					
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	1	1	3	3	3	3
CO2	1	1	3	3	3	3
CO3	1	1	3	3	3	3
CO4	1	1	3	3	3	3
CO5	1	1	3	3	3	3
Average CO	1	1	3	3	3	3

1, 2 and 3 are correlation levels with weightings as Slight (Low), Moderate (Medium) and Substantial (High) respectively

CL3053 FLUIDIZATION ENGINEERING L T P C
3 0 0 3

OBJECTIVES:

- To enable the students to learn the fundamentals of fluidization and its applications.
- To enable the students to understand the basic concept of hydrodynamics in fluidized bed.

- To impart knowledge on bubble dynamics in dense beds.
- To enable the students to encompass the new areas and introduce reactor models specifically for these Contacting regimes.
- To enable the students to understand the fluidization behaviour, write model equations for fluidized beds and design gas-solid fluidized bed reactors.

UNIT I INTRODUCTION 9
Phenomenon of fluidization, behaviour of fluidized beds, Nature of hydrodynamic suspension, Characterization of particles, particle forces, Regimization of the fluidized state, operating models for fluidization systems, Industrial application of fluidized beds

UNIT II HYDRODYNAMICS OF FLUIDIZATION SYSTEMS 9
General bed behaviour, pressure drop, pressure regimes, Incipient Fluidization, Pressure fluctuations, Phase Holdups, Measurements Techniques minimum fluidization velocity, pressure drop, Geldart classification of particles, Fluidization with carryover of particles, mapping of fluidization regimes.

UNIT III DENSE BEDS 9
Distributor types, gas entry region of a bed, gas jets in fluidized beds, pressure drop across distributors, design of a gas distributors, power consumption, Bubbles in dense beds: single rising bubbles, Davidson model for gas flow at bubbles, Evaluation of models for gas flow at bubbles, coalescence and splitting of bubbles, bubble formation. Slug flow.

UNIT IV BUBBLING FLUIDIZED BEDS, ENTRAINMENT AND ELUTRIATION 9
Effect of temperature and pressure on bed properties, Estimation of bed properties, bubble size and bubble growth, physical model and flow model- K-L Model with its Davidson bubbles and wakes, freeboard behaviour, entrainment from tall and short vessels, high velocity fluidization: turbulent fluidized beds and fast fluidization

UNIT V SOLID MOVEMENT, MASS AND HEAT TRANSFER 9
Solid movement, mixing, segregation and staging, gas dispersion and gas interchange in bubbling beds, Particle to gas mass and heat transfer: Experimental interpolation of mass transfer coefficients, experimental heat transfer from bubbling bed model, applications of two phase and three phase fluidized beds.

TOTAL: 45 PERIODS

COURSE OUTCOMES
CO1: Recall the basics of fluidization and know the various industrial applications of fluidization
CO2: Demonstrate the concepts of hydrodynamics in fluidized bed
CO3: Describe the formation and growth of bubble dynamics in dense beds
CO4: Analyze the bed behavior for various geometries of fluidized beds
CO5: Evaluate the transport processes of fluidized beds

REFERENCE BOOKS

1. Kunii, D. and Levenspiel, O., “Fluidization Engineering”, 2nd Edn., Butterworth Heinemann, London, 1990.
2. Fan, L. S., “Gas- liquid Solid Fluidization Engineering”, Butterworths, 1989,
3. Kwauk, M., “Fluidization - Idealized and Bubbleless, with applications”, Science Press, 2009

Course Articulation Matrix:

Course outcomes	PO1	PO2	PO3	PO4	PO5	PO6
CO1	-	-	3	-	-	-

CO2	-	-	2	1	1	-
CO3	1	-	2	1	2	-
CO4	1	-	2	2	1	-
CO5	1	-	1	1	2	-
Average CO	**1**	**-**	**2**	**1.25**	**1.5**	**-**

1, 2 and 3 are correlation levels with weightings as Slight (Low), Moderate (Medium) and Substantial (High) respectively

PP3251 MULTICOMPONENT DISTILLATION L T P C
3 0 0 3

OBJECTIVES:

1. To enable the students to learn the thermodynamic principles involved in VLE and the nonideal behavior and characterize using activity and fugacity coefficients.
2. To enable the students to learn about bubble point and dew point temperatures for multicomponent mixtures.
3. To enable the students to learn the column sequencing for distillation trains and evaluate rigorous methods of distillation design.
4. To impart knowledge about Kb method and Lewis Matheson calculation.
5. To enable the students to study about staged columns for separation of multicomponent and petroleum mixtures.

UNIT I OVERVIEW OF MULTICOMPONENT DISTILLATION 9

Fundamental principles involved in the separation of multi-component mixtures; Determination of bubble-point and Dew Point Temperatures for multi-component mixtures; equilibrium flash distillation calculations for multi-component mixtures, Multiflash calculations

UNIT II THERMODYNAMICS FOR MULTICOMPONENT DISTILLATION 9

Fundamental Thermodynamic principles involved in the calculation of vapor-liquid equilibria and enthalpies of multi-component mixtures; Use of multiple equations of state for the calculation of K values – DePriester Charts, Estimation of the fugacity coefficients for the vapor phase of polar gas mixtures – calculation of liquid, phase activity coefficient; Residue curve bundles – Matrix Description of Residue curve structure.

UNIT III CONSIDERATION IN COLUMN DESIGN 9

General considerations in the design of columns, Column sequencing – Heuristics for column sequencing, Key components – Distributed components – Non-Distributed components – Adjacent keys. Definition of minimum reflux ratio – calculation of Rmin for multi-component distillation – Underwood method – Colburn method – Smoker's equation – Pinch technology.

UNIT IV METHODS FOR COLUMN DESIGN 9

Theta method of convergence – Kb method and the constant composition method, Application of the Theta method to complex columns and to system of columns – Lewis Matheson method – Thick and Geddes, Stage and reflux requirements – Short cut methods and Simplified graphical procedures – Hengstebeck Diagrams – Minimum reflux by Hengstebeck Diagrams – Key ratio Plots.

UNIT V TYPES OF MULTICOMPONENT DISTILLATION COLUMN 9

Hydro treating of oil fractions - Fundamentals of HDT, Reactor modelling and simulation, Catalytic reactors for fuel processing, Basic reactions for fuel processing, Reactor design and fabrication, water gas-shift reactors; modelling of catalytic deoxygenation of fatty acids:

model equations, adsorption parameter evaluation, particle diffusion and parameter estimation study.

TOTAL: 45 PERIODS

COURSE OUTCOMES

CO1: Explain the thermodynamic principles involved in VLE and the nonideal behavior and characterize using activity and fugacity coefficients.
CO2: Evaluate bubble point and dew point temperatures for multicomponent mixtures.
CO3: Apply column sequencing for distillation trains, evaluate rigorous methods of distillation design.
CO4: Practice Kb method and Lewis Matheson calculation.
CO5: Design staged columns for separation of multicomponent and petroleum mixtures.

REFERENCE BOOKS

1. Holland, C. D. Fundamentals of multicomponent distillation. McGraw-Hill. 1981.
2. Kister, H. Z., Haas, J. R., Hart, D. R., & Gill, D. R. Distillation design (Vol. 1). New York: McGraw-Hill. 1992.
3. Petlyuk, F. B. Distillation theory and its application to optimal design of separation units. Cambridge University Press. 2004.
4. Towler, G., &Sinnott, R. K. Chemical engineering design: principles, practice and economics of plant and process design. Elsevier. 2012.
5. Holland, C. D. Multicomponent distillation. Prentice-Hall. 1963.
6. Seader, Junior D., Ernest J. Henley, and D. Keith Roper., "Separation process principles: With applications using process simulators", John Wiley & Sons, 2016.
7. Mc Cabe, Warren L., Julian C. Smith, and Peter Harriott., "Unit operation of chemical engineering", McGraw-Hill, 2018.

Course Articulation Matrix:

Course Outcomes	Program Outcomes					
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO1	1	1	2	1	-	2
CO2	3	2	2	2	1	2
CO3	3	3	3	2	2	2
CO4	3	3	3	2	2	2
CO5	3	3	2	2	2	2
Average CO	2.60	2.40	2.40	1.80	1.75	2.00

1, 2 and 3 are correlation levels with weightings as Slight (Low), Moderate (Medium) and Substantial (High) respectively.

CL3004 NANOCOMPOSITES

L	T	P	C
3	0	0	3

OBJECTIVES:

- To impart knowledge in nano composite materials in engineering applications
- To enable the students to learn and apply principles of various metal oxide nano composite preparation
- To enable the students to understand polymeric nano composite synthesis
- To enable the students to learn biological synthesis of nano composites
- To enable the students to understand preparation of natural nano composites

UNIT I INTRODUCTION 9

Definition- importance of nanocomposites- nano composite materials-classification of composites- metal/ceramics, metal / polymer, Carbon-carbon composites, nano composites ,influence of size, shape and role of interface in composites applications.

UNIT II PREPARATION AND PROPERTIES 9

Hydroxyapatite composites with zirconia, alumina and titania – preparation and properties. SiC whisker reinforced hydroxyapatite and bioactive glass ceramics composites, zirconia toughened and bioactive glass ceramics composites, bioglass-hydroxyapatite composites, carbon composites

UNIT III PHYSICAL AND MECHANICAL PROPERTIES 9

Elastic and strength properties – fracture behavior – fibre matrix load transfer – failure of a composite – criteria, damage of composites from physical and mechanisms to modeling, long term behavior of composite materials, high temperature stability – wear and friction

UNIT IV STRUCTURES OF NANOCOMPOSITES 9

Nanotubes, nanoparticles and inorganic-organic hybrid systems: Single walled carbon nanotubes in epoxy composites; Fullerene/carbon nanotube (CNT) composites; Filled polymer nanocomposites containing functional nanoparticles; Polymer/calcium carbonate nanocomposites; Magnetic polymer nanocomposites; Phenolic resin/SiO_2 organic-inorganic hybrid nanocomposites; Polymer/graphite nanocomposites; Wear resisting polymer nanocomposites: Preparation and properties

UNIT V NATURAL NANOCOMPOSITES 9

Natural nanocomposites: Nanocomposites synthesized biologically; Nanocomposites synthesized by mimicking natural processes; Packaging proteins. Nanocomposite materials modeling: current issues. Multiscale modeling. Multi-physics modeling.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

CO1: Demonstrate the various engineering application of nano composites.
CO2: Explain various metal oxide nano composite preparation
CO3: Determine the physical and chemical properties of nano composites
CO4: Arrange biological synthesis of nano composites
CO5: Design and develop natural nanocomposites and multiscale modeling.

REFERENCE BOOKS

1. Yiu-Wing Mai Zhong-Zhen Yu, , Polymer Nanocomposites, 1st Edition, Woodhead Publishing, 2006
2. Krishan Kumar Chawla, Composite Materials: Science and Engineering, springer, 2012
3. Nanocomposite science and technology, Pulikel M. Ajayan, Wiley-VCH, 2005
4. Ajayan P.M. Nanocomposite Science and Technology, Wiley Verlag GmbH, Weinheim, 2003, ISBN 3-527-30359-6

Course Articulation Matrix:

Course Outcomes	Program Outcomes					
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	2	2	1	2	1	-
CO2	2	1	1	2	1	-
CO3	2	2	-	2	1	-
CO4	-	3	1	-	-	2
CO5	-	-	1	-	1	-
Average CO	2	2	1	2	1	2

1, 2 and 3 are correlation levels with weightings as Slight (Low), Moderate (Medium) and Substantial (High) respectively

CL3005 THERMAL PROCESSING OF FOOD PRODUCTS L T P C
3 0 0 3

OBJECTIVES:

- To enable the students recall the fundamentals of Mass and Energy balance and to apply them in the design of various thermal processing methods
- To enable the students understand the principle, equipment types of low temperature processing and preservation methods
- To impart knowledge of the drying techniques in food processing and preservation
- To enable the students comprehend the working principle and equipment types of different aseptic processing methods of food products
- To impart sound working knowledge of various emerging food processing and preservation technologies

UNIT I PRINCIPLES OF MASS AND ENERGY BALANCE 9

Material Balances-Basic Principles, Material Balance Problems Involved in Dilution, Concentration, and Dehydration, Blending of Food Ingredient, Multistage Processes; Energy Balances-General Principles, Enthalpy Changes in Foods During Freezing, Properties of Saturated and Superheated Steam. Heat balance.

UNIT II PROCESSING AND PRESERVATION BY LOW TEMPERATURE METHODS 9

Use of low temperature – Principles, equipment and effect on quality: Chilling, cold storage. Principles of food freezing: freezing point of foods, Psychrometric chart, Freeze concentration, Freeze drying, IQF. New direction in freeze bed drying, cyclic pressure freeze drying. Freezing of foods, types of freezing equipment,. Methods of freeze concentration, design problems.

UNIT III DRYING 9

Principles of drying, drying rate, factors affecting heat and mass transfer during drying, properties of air-water mixtures; different drying methods: tray, drum, foam mat, spray, and other newer drying methods; construction and design of drying equipment; adiabatic driers. Dehydration of fruits, vegetables, milk, animal products and ready to eat food products. Design parameters of different types of dryers.

UNIT IV ASEPTIC PROCESSING 9

Heat Sterilization. Canning and Retort treatment of foods; spoilage of canned foods, storage of canned foods; Influence of canning on the quality of food; improvement in canning technology. Pasteurization, TST and UHT treatment of milk, fruit juices and other liquid foods. In Package and In flow thermal processing equipment - plate, spiral and shell and tube heat exchangers.

UNIT V EMERGING PROCESSING TECHNOLOGIES 9

High Pressure Processing – principles, mechanism of action, advantages and disadvantages over conventional processing; Equipment and applications in food industry, Pulsed electric field and Ultrasound processing - principles, mechanism of action, advantages and disadvantages over conventional processing; Equipment and applications in food industry. Dielectric and Ohmic heating of foods - principles, mechanism of action, advantages and disadvantages over conventional processing; equipment and applications in food industry. Infra – red heating – principles, mechanism of action food application. Principles of radiation processing, applications like disinfestation, pasteurization and sterilization, extending shelf life of plant products, advantages and limitations.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

CO1: Recognize and recall engineering principles to food processing

CO2: Develop problem solving ability on types of loads and capability to design cold storage systems for food products

CO3: Interpret the role of drying in the preservation of different foods

CO4: Apply the principles of aseptic processing of foods

CO5: Describe the recent developments in food processing and preservation techniques

REFERENCE BOOKS:

1. Toledo, R.M. "Fundamentals of Food Process Engineering", 3rd Edition, Springer, 2007
2. Fellows, P. J. "Food Processing Technology: Principles and Practices", Wood Head Publishing, 1997
3. Barbosa-Canovas, Gustavo et al., "Novel Food Processing Technologies", Marcel Dekker/CRC, 2005
4. Lopez, G.A. and Barbosa, C.G.V. "Food Plant Design", Taylor & Francis, 2005
5. S. Yanniotis, B. Sunden, Heat Transfer in Food Processing, Recent Developments and Applications, WIT Press, Southampton, 2007
6. Ranganna, S. "Handbook of Canning and Aseptic Packaging" Vol. I, II & III, Tata McGraw – Hill, 2000

Course Articulation Matrix:

Course Outcomes	**Program Outcomes**					
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	1	1	2	1	2	1
CO2	1	1	3	1	1	-
CO3	1	1	2	1	1	1
CO4	1	1	2	1	1	-
CO5	1	1	2	1	1	1
Average CO	**1**	**1**	**2.2**	**1**	**1.2**	**1**

1, 2 and 3 are correlation levels with weightings as Slight (Low), Moderate (Medium) and Substantial (High) respectively

CL3006 BIOPROCESS TECHNOLOGY L T P C

3 0 0 3

OBJECTIVES:

- To enable the students to learn the basics of bioprocessing
- To enable the students to understand the DNA structure
- To enable the students to calculate the mass and energy balances
- To enable the students to understand the upstream processes
- To enable the students to learn the downstream processes

UNIT I FRONTIERS OF BIOPROCESSING 9

Defining Bioprocessing, Current and Emerging Trends in Bioprocess Engineering, Materials Advances, Nanoscale advances, Bioprocessing for Chemical and Biologic Product Manufacturing, Bioprocessing Leaders Worldwide Economic Predictions and Careers in Bioprocess Engineering, Skills Needed for Future Bioprocess Engineers.

UNIT II INTRODUCTION TO CELLULAR MICROBIOLOGY 9

DNA Structure, RNA Structure, Protein Structure and Function, Carbohydrates, Lipids, Fats, and Steroids, Basic Metabolic Pathways, General Cell Structure Eukaryotes, Prokaryotes, Archaea, and Viruses, Intracellular Organelles, Cellular Transport.

UNIT III REACTION STOICHIOMETRY, THERMODYNAMICS, AND KINETICS 9

Mass and Energy Balances, Fundamentals of Chemical Reactions, Basic Mass Transfer: Diffusion and Convection, Basic Fluid Dynamics, Basic Thermodynamics, Basic Reaction Kinetics.

UNIT IV UPSTREAM PROCESSING 9

Bioreactors, Batch Culture, Continuous Culture, Fed-Batch Culture, Perfusion Culture, Suspension Culture, Microcarrier Support ,Roller Bottle Culture System, Spinner Flask Culture, Other Scale up Options, Wave Bioreactor, Cell Cube Technology, Rotary Culture System ,Media

UNIT V DOWN STREAM PROCESSING 9

Purification Processes - Centrifugation, adsorption, Electrophoresis, Crystallization Protein Properties, Chromatography, Scale-up and Optimization,

TOTAL: 45 PERIODS

COURSE OUTCOMES:

CO1: Recognize all Bioprocesses and need of chemical basics in bioprocesses.
CO2: Describe the basic of cell and its internal constituents
CO3: Apply reaction mechanisms in terms of chemical kinetics.
CO4: Analyze all unit operations in upstream process in manufacturing Industries.
CO5: Evaluate the downstream processing and industrial bioreactors

REFERENCE BOOKS:

1. Bioprocess engineering principles, Pauline M. Doran, 2nd ed, Academic Press, 2012.
2. Biochemical engineering fundamentals by J.E.Bailey and D.F.Ollis, 2nd ed, 1986, McGraw Hill.
3. Bioprocess Engineering by Michael L. Shuler and Fikret Kargi, 2nd edition, Pearson education.
4. Biochemical engineering by James M.Lee – Prentice-Hall-1992
5. Fundamentals of Modern Bioprocessing by Sarfaraz K. Niazi, Justin L. Brown, CRC Press, 2017.
6. Biochemical Engineering, H.W. Blanch and D.S. Clark, Marcel Dekker, 1997

Course Articulation Matrix:

Course Outcomes	Program Outcomes					
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO1	-	3	1	2	-	-
CO2	1	1	1	2	-	-
CO3	-	3	1	2	3	-
CO4	3	1	1	3	2	-
CO5	1	2	1	-	-	-
Average CO	3	1	2	1	2	1

1, 2 and 3 are correlation levels with weightings as Slight (Low), Moderate (Medium) and Substantial (High) respectively

CL3051 COMPUTATIONAL FLUID DYNAMICS

L	T	P	C
3	0	0	3

OBJECTIVES:

- To impart knowledge on basics of CFD and reminisce conservation principle
- To enable the students to understand discretization techniques
- To enable the students to learn the numerical analysis of solving diffusion in 1D, 2D and 3D
- To impart knowledge on numerical analysis of solving of convection-diffusion problems
- To impart the knowledge of turbulence modelling and grid generation

UNIT I INTRODUCTION AND PRINCIPLES OF CONSERVATION 9

Basics of Computational Fluid Dynamics, Illustration of the CFD approach, CFD as an engineering analysis tool, CFD application in Chemical Engineering, Fundamental principles of conservation, governing equations of fluid flow, heat and mass transfer. Equations of continuity, motion and energy in differential and integral forms, conservation and non-conservation form.

UNIT II DISCRETISATION TECHNIQUES: FINITE DIFFERNCE APPROXIMATION 9

Classification of Partial Differential Equations, Mathematical behaviour of PDE, Basic aspects of discretization, Discretization techniques using finite difference methods – Taylor's Series, explicit and implicit methods. Error and stability analysis

UNIT III DIFFUSION PROCESSES: FINITE VOLUME METHOD 9

Steady one-dimensional diffusion, two and three dimensional steady state diffusion problems, Solution of discretised equations.

UNIT IV CONVECTION - DIFFUSION PROCESSES: FINITE VOLUME METHOD 9

One dimensional convection – diffusion problem, Central difference scheme, upwind scheme, Hybrid and power law discretization techniques, QUICK scheme, Assessment of discretization scheme properties, Solution of discretised equations.

UNIT V TURBULENCE MODELING AND GRID GENERATION 9

Characteristics of turbulent flows, time averaged Navier Stokes equations, turbulence Models – one and two equation, Reynolds stress, LES and DNS. Physical aspects of Grid generation, staggered grid, SIMPLE algorithm, PISO algorithm

TOTAL: 45 PERIODS

COURSE OUTCOMES:

CO1: Describe the basics of CFD and governing equations for conservation of mass momentum and energy

CO2: Analyze the mathematical characteristics of partial differential equations.

CO3: Solve computational solution techniques for time integration of ordinary differential equations

CO4: Formulate various discretization techniques used in CFD

CO5: Assess various turbulence models and grid generation techniques

REFERENCE BOOKS

1. Anderson, J. D., "Computational Fluid Dynamics: The Basics with Applications", McGraw Hill, 1995.
2. Versteeg, H.K. and Malalasekera, W., "An Introduction to Computational Fluid Dynamics: The Finite Volume Method", Pearson Education Ltd., 2007.
3. Chung T.J Computational Fluid Dynamics Cambridge University Press 2003.
4. Fletcher, C. A. J., "Computational Techniques for Fluid Dynamics", Springer Verlag, 1997.

5. Muralidhar, K., and Sundararajan, T., “Computational Fluid Flow and Heat Transfer”,Narosa Publishing House, New Delhi, 2001.
6. Ghoshdastidar, P.S., “Computer Simulation of flow and heat transfer” Tata McGraw – Hill Publishing Company Ltd. 1998.
7. Subas, V. Patankar “Numerical heat transfer fluid flow”, Hemisphere Publishing Corporation, 1980.
8. Taylor, C and Hughes, J.B. “Finite Element Programming of the Navier Stoke Equation”,Pineridge Press Limited, U.K., 1981.

Course Articulation Matrix:

Course Outcomes	Program Outcomes					
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	-	-	-	2	-	-
CO2	1	-	2	1	2	2
CO3	1	-	2	3	3	2
CO4	1	-	2	3	2	2
CO5	-	-	2	1	1	1
Average CO	1	-	2	2	2	1.75

1, 2 and 3 are correlation levels with weightings as Slight (Low), Moderate (Medium) and Substantial (High) respectivel

CL3052 DESIGN OF EXPERIMENTS **L T P C**
2 0 2 3

OBJECTIVES:

- To impart knowledge on sampling and sampling distribution and to apply hypothesis testing with different confidence intervals
- To enable the students, develop skills in linear regression, both univariate and multivariate, and utilize least squares methods to estimate and interpret regression models.
- To enable the students to interpret experimental results using ANOVA, report data, and construct confidence intervals.
- To enable the students to perform ANOVA and regression analysis
- To enable the students to explore variable selection, fractional factorial design, and robustness in experimental design.

UNIT I FOUNDATIONS OF PROBABILITY AND STATISTICS FOR ENGINEERS 6

Introduction to probability and statistics - including concepts and principles; Statistical inference fundamentals - such as estimation and hypothesis testing; Confidence intervals - providing a range of plausible values for population parameters; Hypothesis tests to make decisions based on experimental data.

UNIT II PRINCIPLES OF EXPERIMENTAL DESIGN 6

Statistical principles in experimental design - including the control of sources of variation; Blocking and complete randomization techniques; Factorial design to study the effects of multiple factors on the response variable; Analysis of individual factor effects and interaction effects; Introduction to response surface methodologies for optimizing response variables within a design space.

UNIT III REGRESSION MODELING AND ANALYSIS 6

Linear regression techniques - both univariate and multivariate - to model relationships between variables; Least Squares estimation - including its basic principles and variants;

Nonlinear regression methods to model non-linear relationships; Techniques for model assessment, interpretation, and evaluation of regression models.

UNIT IV ANALYSIS OF VARIANCE AND EXPERIMENTAL INFERENCE 6

Introduction to ANOVA - a statistical technique for comparing means among multiple groups or treatments; Interpretation of results from experiments using ANOVA; Effective reporting of experimental data; Construction of confidence intervals to estimate population means and differences.

UNIT V ADVANCED TOPICS IN STATISTICS AND EXPERIMENTAL DESIGN 6

Exploration of additional topics in statistics and experimental design; Variable selection techniques to identify significant factors in regression models; Fractional factorial design for efficient exploration of factor combinations; Robustness in experimental design and analysis - focusing on the stability and reliability of statistical methods in the presence of deviations from assumptions.

THEORY 30 PERIODS

List of tasks to be performed by students: Software Minitab/Equivalent Alternative

PRACTICAL: 30 PERIODS

1) Exploratory Data Analysis: Import a dataset into Minitab and perform exploratory data analysis; Calculate descriptive statistics - such as mean, median, and standard deviation; Create graphical representations of the data, including histograms, box plots, and scatter plots.

2) Probability Distribution Analysis: Generate random numbers from different probability distributions in Minitab - such as normal, exponential, or binomial; Fit probability distributions to data and assess goodness-of-fit using Minitab's distribution fitting tools.

3) Hypothesis Testing and Confidence Intervals: Formulate hypotheses and perform hypothesis tests using Minitab for various scenarios; Conduct t-tests, chi-square tests, or ANOVA tests to compare population means or proportions.

4) Experimental Design and Analysis: Design and execute experiments using Minitab's design of experiments (DOE) tools; Analyze the results of designed experiments - including factorial designs, using Minitab's DOE analysis features; Assess the significance of factor effects and interaction effects.

5) Regression Modeling and Analysis: Perform linear regression analysis in Minitab to model relationships between variables; Interpret the coefficients and significance of predictors in regression models; Assess the goodness-of-fit and validity of regression models using diagnostic plots and statistical tests in Minitab.

TOTAL: 60 PERIODS

COURSE OUTCOMES:

CO1: Recognize and recall foundational probability and statistics concepts and apply them to solve engineering problems.

CO2: Apply statistical inference techniques to draw conclusions from experimental data.

CO3: Analyze variance (ANOVA) technique and apply it to experimental design and interpretation of results.

CO4: Illustrate skills in linear regression modeling and interpret regression models for engineering applications.

CO5: Apply statistical principles to experimental design and assess model adequacy for regression models.

CO6: Recall and apply foundational statistical concepts in practical data analysis using software tools like Minitab.

CO7 Demonstrate proficiency in conducting hypothesis tests, constructing confidence intervals, and analyzing experimental data using software.

CO8: Analyze regression models, interpret their coefficients, and evaluate model adequacy through diagnostic plots and statistical tests using software.

REFERENCE BOOKS:

1. R.L. Mason, R.F. Gunst and J.L. Hess (2005). Statistical Design and Analysis of Experiments – with applications to engineering and science, 2 nd edition, John Wiley & Sons
2. Design of Experiments in Chemical Engineering: A Practical Guide by Z. R. Lazic, John Wiley
3. R.A. Johnson, I. Miller and J. Freund (2007). Probability and Statistics for Engineers, 7 th edition, Prentice Hall Inc.
4. D.C. Montgomery and G.C. Runger (2007). Applied Statistics and Probability for Engineers, 4th edition, John Wiley & Sons Inc.
5. Box, George EP, J. Stuart Hunter, and William G. Hunter. "Statistics for experimenters." In Wiley series in probability and statistics. Hoboken, NJ: Wiley, 2005.

Course Articulation Matrix:

Course Outcomes	Program Outcomes					
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	3	1	3	1	1	1
CO2	1	3	1	1	3	1
CO3	1	1	3	1	1	1
CO4	2	1	3	1	1	1
CO5	1	1	1	1	3	1
CO6	1	1	2	2	3	2
CO7	3	2	2	2	3	2
CO8	2	1	1	2	3	2
Average CO	1.80	1.40	2.00	1.40	2.30	1.40

1, 2 and 3 are correlation levels with weightings as Slight (Low), Moderate (Medium) and Substantial (High) respectively

CL3055 SUSTAINABLE MANAGEMENT

L	T	P	C
3	0	0	3

OBJECTIVES

- To enable the students to learn the fundamentals of sustainability in the context of engineering.
- To enable the students to analyze the environmental impact of chemical processes and identify opportunities for improvement.
- To impart knowledge on sustainable process design and optimization techniques.
- To enable the students to evaluate energy efficiency and resource conservation strategies in industries/ plants.
- To enable the students to develop skills for implementing sustainable practices in engineering projects and operations.

UNIT I INTRODUCTION TO SUSTAINABLE MANAGEMENT 9

Overview of sustainability principles and their relevance to chemical/petroleum/environmental engineering; Environmental challenges in the chemical industry; Introduction to sustainable development goals and their application in chemical engineering; Role of engineers in promoting sustainability; Introduction to life cycle assessment (LCA) and environmental impact analysis.

UNIT II SUSTAINABLE PROCESS DESIGN AND OPTIMIZATION 9

Principles and strategies for sustainable process design, Analysis and optimization of chemical processes for sustainability; Integration of green chemistry principles in process design; Case studies on sustainable process design in chemical engineering; Tools and software for sustainable process design and optimization.

UNIT III ENERGY EFFICIENCY AND CONSERVATION 9

Energy consumption and environmental impact of chemical processes; Strategies for improving energy efficiency in chemical plants; Energy conservation techniques in heat transfer, separation processes, and reactions; Integration of renewable energy sources in chemical processes; Case studies on energy-efficient operations in chemical engineering.

UNIT IV WASTE MINIMIZATION AND RESOURCE RECOVERY 9

Waste generation in chemical processes and its impact on the environment; Techniques for waste minimization and treatment; Resource recovery from waste streams, Recycling and circular economy principles in chemical engineering; Case studies on waste reduction and resource recovery in chemical processes.

UNIT V SUSTAINABLE SUPPLY CHAIN MANAGEMENT IN INDUSTRY 9

Sustainability considerations in the chemical supply chain; Responsible sourcing of raw materials, Green packaging and logistics practices; Supplier assessment and management for sustainability; Certification systems and standards for sustainable supply chains.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

CO1: Identify and discuss the key principles and concepts of sustainability in the context of engineering.

CO2: Analyze and evaluate the environmental impact of chemical processes and propose sustainable solutions.

CO3: Design and optimize chemical processes considering sustainability factors and green chemistry principles.

CO4: Assess and implement energy-efficient strategies and resource conservation techniques in chemical plants.

CO5: Apply sustainable supply chain management principles to ensure responsible sourcing and minimize environmental impact.

REFERENCE BOOKS

1. Beder, Sharon., "Environmental principles and policies: an interdisciplinary introduction", Routledge, 2013.
2. Elkington, John, and Ian H. Rowlands. "Cannibals with forks: The triple bottom line of 21st century business." Alternatives Journal 25, no. 4,42, 1999.
3. Fiksel, Joseph. Design for environment: a guide to sustainable product development. McGraw-Hill Education, 2009.
4. Johansson, Allan. Clean technology. CRC Press, 1992.
5. Kane, Gareth. The green executive: corporate leadership in a low carbon economy. Routledge, 2012.
6. Kirkwood, Ralph, and Anite Longley, eds. Clean technology and the environment. Springer Science & Business Media, 1994.
7. Mulder, Karel, ed. Sustainable development for engineers: A handbook and resource guide. Routledge, 2017.
8. Marinova, Dora, David Annandale, and John Phillimore, eds. The international handbook on environmental technology management. Edward Elgar Publishing, 2008.
9. Von Weizsäcker, Ernst Ulrich, Amory B. Lovins, and L. Hunter Lovins. Factor four: doubling wealth—halving resource use: a new report to the club of Rome. Springer International Publishing, 2014.

10. Willums, Jan-Olaf. The sustainable business challenge: a briefing for tomorrow's business leaders. Routledge, 1998.
11. Harmsen, Jan, and Joseph B. Powell. Sustainable development in the process industries. Hoboken, NJ: John Wiley & Sons, 2010.

Course Articulation Matrix:

Course Outcomes	Program Outcomes					
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	3	3	3	1	1	1
CO2	1	2	2	3	3	2
CO3	2	3	3	3	3	2
CO4	2	2	1	3	1	1
CO5	1	2	2	2	3	2
Average CO	**1.80**	**2.40**	**2.20**	**2.40**	**2.20**	**1.60**

1, 2 and 3 are correlation levels with weightings as Slight (Low), Moderate (Medium) and Substantial (High) respectively.

PP3051 MULTIPHASE FLOW

L	T	P	C
3	0	0	3

OBJECTIVES:

- To enable the students to understand the significance of multiphase flows and different flow pattern in multiphase flow
- To enable the students to determine the hydrodynamic parameters in the multiphase flow system
- To enable the students to understand the concept of different flow models in different phases.
- To enable the students to understand the one-dimensional two-dimensional flow equation in turbulent condition
- To enable the students to understand the Hydrodynamic characteristics in different contactors

UNIT I INTRODUCTION 9

Introduction to Multiphase Flow, Scope and significance of multiphase flows, Dimensionless numbers in multiphase flows; Flow Pattern and Flow Regimes: Fluid-Solid System, Fluid-Fluid Systems, Solid- Fluid-Fluid systems. Flow patterns in pipes, analysis of two phase flow situations. Two-phase Co- current flow of Gas-Liquid, Gas-Solid and Liquid-Liquid, Upward and Downward Flow in Vertical pipes. Suspensions of Solid and their transport in Horizontal Pipes. Drag Reduction Phenomena, Laminar, Turbulent and Creeping Flow Regimes.

UNIT II PREDICTION 9

Prediction of holdup and pressure drop or volume fraction, Bubble size in pipe flow, Lock chart- Martinelli parameters, Bubble column and its design aspects, Minimum carryover velocity. holdup ratios, pressure drop and transport velocities and their prediction.

UNIT III MODELS 9

Flow patterns - identification and classification - flow pattern maps and transition - momentum and energy balance - homogeneous and separated flow models - correlations for use with homogeneous and separated flow models - void fraction and slip ratio correlations - influence of pressure gradient - empirical treatment of two-phase flow -

drift flux model - correlations for bubble, slug and annular flows

UNIT IV AVERAGING PROCEDURES 9

Averaging procedures - time, volume, and ensemble averaging, quasi-one-dimensional flow, two-fluid volume-averaged equations of motion, turbulence and two-way coupling

UNIT V APPLICATIONS 9

Flow regime Hydrodynamic characteristics of gas-solid liquid contactors (agitated vessels, packed bed, fluidized bed, pneumatic conveying, bubble column, trickle beds), Applications of these contactors. Measurement techniques in multiphase flow: Conventional and novel measurement techniques for multiphase systems (Carpt ,Laser Doppler anemometry, Particle Image Velocimetry)

TOTAL: 45 PERIODS

COURSE OUTCOMES:

CO1: Explain the significance of multiphase flows and different flow pattern in multiphase flow

CO2: Review the hydrodynamic parameters in the multiphase flow system

CO3: Develop different flow models in multiphase system.

CO4: Formulate the one-dimensional and two-dimensional flow equation in turbulent condition

CO5: Demonstrate the Hydrodynamic characteristics in different contactors

REFERENCE BOOKS

1. Govier, G. W. and Aziz. K., “The Flow of Complex Mixture in Pipes”, Van Nostrand Reinhold, New York, 1972.
2. Clift, R., Weber, M.E. and Grace, J.R., Bubbles, Drops, and Particles, Academic Press, New York, 2005.
3. Crowe, C. T., Sommerfeld, M. and Tsuji, Y., Multiphase Flows with Droplets and Particles, CRC Press, 2011
4. Fan, L. S. and Zhu, C., Principles of Gas-solid Flows, Cambridge University Press, 2005
5. Kleinstreuer, C., Two-phase Flow: Theory and Applications, Taylor & Francis, 2003

Course Articulation Matrix:

Course Outcomes	Program Outcomes					
	PO1	PO2	PO3	PO4	PO5	PO6
CO1	2	3	1	1	2	1
CO2	2	3	1	1	-	1
CO3	2	-	1	1	2	-
CO4	2	3	1	-	2	1
CO5	2	3	1	1	-	-
Average CO	2	3	1	1	2	1

1, 2 and 3 are correlation levels with weightings as Slight (Low), Moderate (Medium) and Substantial (High) respectively

CL3056 POLYMER PROCESSING TECHNOLOGY

L	T	P	C
3	0	0	3

OBJECTIVES:

- To impart knowledge on the types of polymers, polymerization reactions, polymerization techniques.
- To impart knowledge on processing of elastomers and application-oriented polymers.

- To enable the students to learn the analytical characteristics of polymers
- To enable the students to learn the testing procedures of polymer composites
- To impart knowledge on polymer composites

UNIT I GENERAL ASPECTS OF POLYMERS 9

Classification of polymers - natural and synthetic, thermoplastic and thermosetting; types and mechanism of polymerization reactions; polymerization techniques; Polymer properties - degree of polymerization, molecular weight determination, glass transition temperature, crystallinity, thermal, electrical and mechanical properties.

UNIT II POLYMER PROCESSING 9

Process additives and significance; types of additives; mixing processes; Types of moulds; mould cooling and ejection techniques; moulding - extrusion moulding, injection moulding, blow mouldind and other moulding techniques.

UNIT III ELASTOMERS AND APPLICATION ORIENTED POLYMERS 9

Natural Rubber and synthetic rubber; unit operations; styrene – butadiene, polyisopropane – neoprene, silicone rubber, thermoplastic elastomers; Resins – epoxy, phenol formaldehyde, urea formaldehyde; fibrous Polymers - Nylon 66, PAN; PVC, Silicon Oil.

UNIT IV POLYMER TESTING AND CHARACTERIZATION 9

Analytical tests - determination of specific gravity, water absorption; Non-destructive testing - ultrasonic testing, Acoustic emission (AE) testing, thermal stability, X-ray fluorescence, FT-IR, XRD, SEM, AFM, etc.

UNIT V POLYMER COMPOSITES 9

Polymer composites and general concepts; structure and components of polymer composites; classification of polymer composites; hybrid composites; usage areas of composites in daily life.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

CO1: Recall the fundamentals of polymers and mechanism of polymerization techniques and polymer properties.
CO2: Apply the mechanism and effectiveness of polymerization in making finished materials.
CO3: Demonstrate the knowledge of elastomers and its processing.
CO4: Construct the knowledge of analytical characteristics of polymer.
CO5: Assess the general aspects of polymer composite materials.

REFERENCE BOOKS:

1. Birley, Haworth, Batchelor, “Physics of Plastics – Processing Properties and Materials Engineering”, Hamer Publication, 1992.
2. Billmayer F.W., “Text Book of Polymer Science” 3rd Ed., John Wiley and sons, New York, 2002.
3. Richard G. Griskey, “Polymer Process Engineering”, Chapman and Hall, 1995.
4. Vishu Shah, “Hand book of Plastics Testing and Failure Analysis”, 3rd Ed., John-Willey &Sons, New York, 2007.
5. Sabu Thomas, Kuruvilla Josep, “Polymer Composites: Volume 1” 1st Ed., Wiley, 2012.

Course Articulation Matrix:

Course Outcomes	Program Outcomes					
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	-	1	-	2	3	3
CO2	3	3	1	3	3	3
CO3	3	3	1	3	3	3
CO4	-	3	1	-	3	3
CO5	3	3	1	3	3	3
Average CO	2	2.6	1	2.75	3	3

1, 2 and 3 are correlation levels with weightings as Slight (Low), Moderate (Medium) and Substantial (High) respectively

CL3007 BUSINESS ANALYTICS

L	T	P	C
3	0	0	3

OBJECTIVES:

- To enable the students to learn the basics of Business Analytics
- To enable the students understand and analyze descriptive analytics and Hypothesis testing
- To impart knowledge on Data Analytics and Data Visualization
- To enable the students understand and analyze Predictive Analytics
- To enable the students understand and analyze Prescriptive Analytics

UNIT I INTRODUCTION TO BUSINESS ANALYTICS (BA) 9

Business Analytics - Terminologies, Process, Importance, Relationship with Organisational Decision Making, Analytics in Decision Making, BA for Competitive Advantage-Organisational Structures aligning BA. Managing Information policy

UNIT II DESCRIPTIVE ANALYTICS AND HYPOTHESIS TESTING 9

Data and Technology- data quality and change in BA- Descriptive and Inferential Statistics-Mean/Nledian/Mode-Standard Deviation/Covariance/Correlation - Sampling And Estimation - Probability Distribution For Descriptive Analytics - Analysis Of Descriptive Analytics-Hypotheses testing

UNIT III DATA ANALYTICS AND DATA VISUALIZATION 9

An introduction to Data Analytics- Role of Analytics in the Modern World-Types of Analytics: Descriptive, Diagnostic, Predictive, Prescriptive-Data Analytics and Ethical Issues, Data visualizations : Create Visual Representations Of Data In Excel - Create Scatter Plots And Calculate The Correlation Coefficient, Create Boxplot, Create, Historgram and line chart

UNIT IV PREDICTIVE ANALYTICS 9

Introduction to Predictive analytics - Logic and Data Driven Models - Predictive Analysis Modeling and procedure - Data Mining for Predictive analytics. Analysis of Predictive analytics.

UNIT V PRESCRIPTIVE ANALYTICS 9

Introduction to Prescriptive analytics - Prescriptive Modeling - Non Linear Optimisation - Demonstrating Business Performance Improvement.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

CO1: Recall the basics of Business Analytics
CO2: Analyze and apply descriptive analytics and Hypothesis testing
CO3: Illustrate Data Analytics and Data Visualization
CO4: Formulate Predictive Analytics
CO5: Evaluate Prescriptive Analytics

REFERENCE BOOKS:

1. Fundamentals of Business analytics, 2nd Edition,R.N.Prasad and Seema Acharya, wiley india pvt ltd, 2016.
2. Business analytics,U.Dinesh kumar, wiley publisher, 2017.
3. Business analytics-data analysis and decision making with mind map, 7th edition, S. Christian Albright and Wayne L. Winson, 2022.
4. Business analytics methods, models and decisions, 3rd edition, James R Evans, 2017.
5. Business analytics for decision making, 1st edition, Regi Mathew, 2020.

Course Articulation Matrix:

Course Outcomes	Program Outcomes					
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	3	1	2	3	3	1
CO2	3	1	2	3	3	1
CO3	3	1	2	3	3	1
CO4	3	1	2	3	3	1
CO5	3	1	2	3	3	1
Average CO	3	1	2	3	3	1

1, 2 and 3 are correlation levels with weightings as Slight (Low), Moderate (Medium) and Substantial (High) respectively

CL3008 CHEMICAL PROCESSES AND POLLUTION CONTROL

L	T	P	C
3	0	0	3

OBJECTIVES:

- To enable the students to understand the pollutants released from various chemical industries.
- To familiarize the students on options for pollution prevent in chemical processes.
- To impart knowledge on pollutant measurement techniques.
- To develop student’s ability to frame management strategies for the control of pollution.
- To make the students understand the regulation pertaining to pollutant discharge.

UNIT I INDUSTRIAL POLLUTANTS ITS MEASUREMENT 9

Introduction- pollution from chemical process industries, characterization of emission and effluents, standards for ambient air, noise emission and effluents; Analysis of pollutant; Pollutant measurement- Fundamental Units of Measurement – Mass Concentration Parts Per Million and mg/l, Mass Percentage and Mass Fraction, Mass Flow Rates, volume Fraction and Volume Concentration; Converting Volume and Mass Concentration in Gases – Molar Mass and Molar Concentration – Equivalent Weights

UNIT II POLLUTION PREVENTION FOR CHEMICAL PROCESSES 9

Pollution Prevention for Unit Operations; Preventing Fugitive and Secondary Emissions; Flowsheet Analysis for Pollution Prevention; Management of Pollution Prevention Activities at Industrial Facilities - Process modification, alternative raw material, recovery of by co-product from industrial emission effluents; recycle and reuse of waste- energy recovery and waste utilization; Material and energy balance for pollution minimization; Water use minimization.

UNIT III ELEMENTS OF POLLUTION PREVENTION PROGRAMS 9

The Waste Management Hierarchy and the Definition of Pollution Prevention; An Industrial Perspective of Pollution Prevention-The Benefits of Pollution Prevention, Barriers to Pollution Prevention (Industrial Barriers – Regulatory Barriers); The Basic Structure of a Pollution Prevention Program - Identifying Critical Waste Streams; Waste Audits – Emission Inventories (Fugitive Emissions – Secondary Emissions) – Prioritizing Waste Streams.

UNIT IV POLLUTION CONTROL 9

Water Pollution Control- Physical treatment, pre-treatment, solids removal by setting and sedimentation, filtration centrifugation, coagulation and flocculation; Air Pollution Control- Particulate emission control by mechanical separation and electrostatic precipitation, wet gas scrubbing, gaseous emission control by absorption and adsorption, Design of cyclones, ESP, fabric filters and absorbers.

UNIT V REGULATIONS GOVERNING POLLUTANT EMISSIONS 9

Regulations concerning water pollution-WATER (P&CP) ACT, 1974; air pollution- AIR (P&CP) ACT, 1981; solid waste -hazardous Wastes-Hazardous and other Wastes (Management & Transboundary Movement) Rules, 2016; Pollution Prevention Case Study.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

CO1: Identify importance of pollutant measurement and different types of pollution
CO2: Classify pollution control options for different chemical processes.
CO3: Design Hierarchy of Pollution Prevention strategy.
CO4: Choose equipment for pollution control.
CO5: Illustrate regulations governing pollution prevention preventive

REFERENCE BOOKS:

1. Nancy J. Sell, Industrial pollution control: Issues and techniques.
2. Berthouex, P. M., Brown, L. C. (2017). Chemical Processes for Pollution Prevention and Control. United Kingdom: CRC Press
3. "Pollution Control Acts, Rules, Notifications issued there under" CPCB, Ministry of Env. and Forest, G.O.I., 3rd Ed. 2006.
4. Allen, D. T., Rosselot, K. S. Pollution Prevention for Chemical Processes: A Handbook with Solved Problems from Refining and Chemical Processing Industries (1994).
5. Bishop P.E. Pollution Prevention: Fundamentals and Practice, McGraw Hill

Course Articulation Matrix:

Course Outcomes	Program Outcomes					
	PO1	PO2	PO3	PO4	PO5	PO6
CO1	-	3	1	2	-	-
CO2	1	1	1	2	-	-
CO3	-	3	1	2	3	-
CO4	3	1	1	3	2	-
CO5	1	2	1	-	-	-

Average CO	1	2	1	2	1	-

1, 2 and 3 are correlation levels with weightings as Slight (Low), Moderate (Medium) and Substantial (High) respectively

CL3009 RISK ANALYSIS AND MANAGEMENT

L	T	P	C
3	0	0	3

OBJECTIVES:

- To enable the students to learn the principles and terminology related to risk management
- To enable the students to understand the basic quantitative methods on risk identification and risk management
- To impart knowledge on the concepts of risk analysis and management in chemical industries
- To impart knowledge on emergency planning and insurance
- To impart knowledge on handling risk analysis in chemical industries

UNIT I INTRODUCTION 9

Identify key risks; measure probability and impact; risk types; root cause analysis and decision making.

UNIT II RISK ASSESSMENT AND HAZARD IDENTIFICATION 9

introduction and available methodologies - quantitative risk assessment, rapid risk analysis, comprehensive risk analysis; risk identification; evaluation and control of risk; uncertainty in risk assessment; hazard identification - hazard assessment, probabilistic hazard assessment, fault tree analysis, event tree analysis, zero infinity dilemma.

UNIT III RISK MANAGEMENT 9

Risk management plan; mandatory technology option analysis; risk management alternatives; risk management tools; risk management plans; risk index methods; precautionary principles; risk perceptions and communication; behavioral decision making.

UNIT IV EMERGENCY PLANNING AND INSURANCE 9

Overall risk contours for different failure scenarios; disaster management plan; emergency planning; onsite and offsite emergency planning; overview of insurance and risk transfer-property insurance, transport insurance, liability insurance, pecunious insurance.

UNIT V RISK ANALYSIS IN CHEMICAL INDUSTRIES 9

Handling and storage of chemicals; process plants; personnel protection equipments; environmental risk analysis; international environmental management system; corporate management system; environmental risk assessment; total quality management; paradigms and its convergence.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

CO1: Recall the general aspects of risk analysis and management.
CO2: Apply different tools to aid the risk assessment analysis
CO3: Identify characteristics of risk management system
CO4: Assess onsite and offsite emergency planning.
CO5: Analyze risk in Process industries and manage the risks.

REFERENCE BOOKS:

1. Srivastav, S., "Industrial Maintenance Management", Sultan Chand & Co., 1998.
2. Crowl, D. A. and Louvar, J. F., "Chemical process safety; Fundamentals with applications", Prentice Hall Publication Inc., 2002.
3. Fawcett, H. H., "Safety and Accident Prevention in Chemical Operations" John Wiley & Sons, 1982.
4. Kind, R. W., "Industrial Hazard and Safety Handbook" Butterworth, 1982.
5. Steiner, H. M., "Engineering Economic Principles", McGraw Hill Book Co., New York,1996.

Course Articulation Matrix:

Course Outcomes	Program Outcomes					
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	2	3	2	-	-	1
CO2	2	3	2	3	2	3
CO3	2	3	2	3	2	3
CO4	3	3	2	1	2	3
CO5	3	3	2	3	2	3
Average CO	2.4	3	2	2.5	2	2.6

1, 2 and 3 are correlation levels with weightings as Slight (Low), Moderate (Medium) and Substantial (High) respectively

CL3010 PROJECT ENGINEERING OF PROCESS PLANTS **L T P C**
3 0 0 3

OBJECTIVES:

- To enable the students to understand the scope of project engineering
- To enable the students to learn the procedures for procurement and operations
- To enable the students to learn design and selection of pumps, compressors and their accessories
- To impart knowledge on design and selection of piping and building constructions
- To enable the students to learn the evaluation techniques in project engineering

UNIT I SCOPE 9

Scope of project engineering – the role of project engineer – R & D – TEFR – plant location and site selection – preliminary data for construction projects – process engineering – flow diagrams – plot plans – engineering design and drafting. Planning and scheduling of projects – bar chart and network techniques.

UNIT II PROCEDURES 9

Business and legal procedures: Procurement operations, Organization and operation of procurement department, Procurement procedure, General purchaser-vendor practices, contracts and contractors, project financing, statutory sanctions.

UNIT III DESIGN AND SELECTION – I 9

Details of engineering design and equipment selection – design calculations excluded - Vessels, heat exchangers, process pumps, compressors and vacuum pumps, motors and Turbines, other process equipment.

UNIT IV DESIGN AND SELECTION - II 9

Details of engineering design and equipment selection II – design calculations excluded – piping design, thermal insulation and buildings, safety in plant design, plant constructions, start up and commissioning.

UNIT V EVALUATION 9

Critical path method (CPM) and Programme evaluation and review technique (PERT) in project engineering.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

CO1: Recognize the scope of project engineering.
CO2: Analyze and apply the procedures for procurement and operations.
CO3: Choose pumps, compressors and their accessories.
CO4: Design and selection of piping and building constructions.
CO5: Evaluate the reviewing techniques in project engineering.

REFERENCE BOOKS:

1. Peter Watermeyer , Handbook for Process Plant Project Engineers, Wiley, 2002
2. Howard F. Rase, M. H. Barrow, Project engineering of process plants, Wiley, 1957
3. Peter S. Max &Timmerhaus, Plant design and economics for chemical engineers, Mc Graw Hill, 2002.
4. B. C. Punmia & K. K. Khandelwal, Project Planning and Control with PERT & CPM, Firewall Media, 2002
5. Srinath L. S., PERT AND CPM, 3rd Edn Affiliated East Press Pvt. Ltd., New York, 2001.
6. Perry J. H,"Chemical engineering handbook" 7th ed. McGraw Hill, 1997.
7. Ernest E. Ludwig, Applied project engineering and management, Gulf Pub. Co, 1988.
8. R K Sinnott, Chemical Engineering Design: Chemical Engineering Design, Chemical Engineering Technical Series, Elsevier, 2014.

Course Articulation Matrix:

Course Outcomes	Program Outcomes					
	PO1	PO2	PO3	PO4	PO5	PO6
CO1	1	3	3	3	3	3
CO2	3	2	3	3	3	3
CO3	3	1	3	3	3	3
CO4	3	1	3	3	3	3
CO5	3	3	3	3	3	3
Average CO	3	2	3	3	3	3

1, 2 and 3 are correlation levels with weightings as Slight (Low), Moderate (Medium) and Substantial (High) respectively.

CL3011 OPERATIONS RESEARCH L T P C
3 0 0 3

OBJECTIVES:

- To enable the students to solve linear programming problem and solve using graphical method.
- To enable the students to solve LPP using simplex method
- To enable the students to solve transportation, assignment problems
- To enable the students to solve project management problems
- To enable the students to solve scheduling problems

UNIT I LINEAR PROGRAMMING 9

Introduction to Operations Research – assumptions of linear programming problems - Formulations of linear programming problem – Graphical method

UNIT II ADVANCES IN LINEAR PROGRAMMING 9

Solutions to LPP using simplex algorithm- Revised simplex method - primal dual relationships – Dual simplex algorithm - Sensitivity analysis

UNIT III NETWORK ANALYSIS – I 9

Transportation problems -Northwest corner rule, least cost method, Voges's approximation method - Assignment problem -Hungarian algorithm

UNIT IV NETWORK ANALYSIS – II 9

Shortest path problem: Dijkstra's algorithms, Floyds algorithm, systematic method - CPM/PERT

UNIT V NETWORK ANALYSIS – III 9

Scheduling and sequencing - single server and multiple server models - deterministic inventory models - Probabilistic inventory control models

TOTAL: 45 PERIODS

COURSE OUTCOMES:

CO1: Formulate linear programming problem and solve using graphical method.
CO2: Practice LPP using simplex method
CO3: Solve transportation, assignment problems
CO4: Analyze project management problems
CO5: Evaluate scheduling problems

REFERENCE BOOKS:

1. Harvey M Wagner, Principles of Operations Research: Prentice Hall of India 2010.
2. Hitler Libermann, Operations Research: McGraw Hill Pub. 2009.
3. Pant J C, Introduction to Optimisation: Operations Research, Jain Brothers, Delhi, 2008.
4. Pannerselvam, Operations Research: Prentice Hall of India 2010.
5. Taha H A, Operations Research, An Introduction, PHI, 2008

Course Articulation Matrix:

Course Outcomes	Program Outcomes					
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	1	2	2	2	3	3
CO2	1	1	3	1	3	3
CO3	1	1	3	2	3	3
CO4	1	2	3	2	3	3
CO5	1	2	3	2	2	3
Average CO	1	2	3	3	2	3

1, 2 and 3 are correlation levels with weightings as Slight (Low), Moderate (Medium) and Substantial (High) respectively.

CL3012 SAFETY AND ENVIRONMENT IN CHEMICAL INDUSTRIES **L T P C**
3 0 0 3

OBJECTIVES:

- To make the students analyze the Root causes of accidents and effects on human beings and materials
- To enable the students to understand the theories, structures and prevention of accidents
- To impart knowledge on industrial safety of a chemical process plant.
- To enable the students to understand the applications and advantages of good house keeping
- To enable the students to learn the Disaster managements and various issues

UNIT I LEGISLATION AND POLICY 9

Safety, safety responsibility and organization, OHS, safety policy, safety inspection, employees participation in safety, safety legislation, plant siting and layout, utilities and safety, regulatory agencies with safety in India and Abroad, types of accidents in industry, case study.

UNIT II INDUSTRIAL HAZARD AND ASSESSMENT 9

Industrial hazard, hazard management program, hazard identification and assessment, Material hazard: Toxicity, Radiation, Flammability, fires, explosion, runaway chemical reaction, MSDS sheet, list of industries involving hazardous process, Factory Act, 1948

UNIT III HAZARD CONTROL 9

Environment, Need for environment control, lighting, importance of adequate lighting, lighting design, colour codes used in industry, heat control, ventilation and air conditioning, legal requirements, noise, noise measurement and control, vibration, industrial fatigue, EIA

UNIT IV WASTE CLASSIFICATIONS AND PPE 9

Industrial waste, waste classification, waste water treatment, waste disposal, storage, transportation of hazardous materials occupational health problems, Fire management, medical examination in industry, PPE, Training & Maintenance of PPE.

UNIT V SAFETY STANDARDS AND AUDIT 9

Quality standards, ISO 9000, ISO9000 : 2000 Quality Management principles, Benefits, workplace emergency, emergency planning, on–site and offsite planning, fire emergency procedure, safety symbols, safety signs and colour at work, training, safety audit.

TOTAL: 45 PERIODS

COURSE OUTCOMES

CO1: List the importance of industrial safety and safety regulations all over the world.
CO2: Discuss the effect of material hazard Evaluate the importance of EIA in chemical industries
CO3: Classify the industrial waste and recommend the relevant PPE
CO4: Describe quality management principles and the importance of emergency planning.
CO5: Practice industrial safety, environmental impact, rules and regulations

REFERENCE BOOKS:

1. Industrial Safety and Environment, Amit Kumar Gupta, Laxmi Publications Ltd., 2006
2. Chemical process industrial safety, KSN Raju, McGraw Hill, 2014
3. M.N.Vyas, Safety and hazards management in chemical industries, Atlantic publishers,2020
4. Lees' Loss Prevention in the Process Industries: Hazard Identification, Assessment and Control, Volume 1, edited bySam Mannan, third edition, 2005

5. Pravin M. Pathak , Jayant P. Khairnar Industrial Safety Management : Safety Health And Environment Management, 2022

Course Articulation Matrix:

Course Outcomes	Program Outcomes					
	PO 1	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**
CO1	1	3	1	2	1	1
CO2	1	1	1	2	1	1
CO3	2	3	1	2	3	1
CO4	3	1	1	3	2	1
CO5	1	2	1	1	2	1
Average CO	1.6	2	1	1.8	1.8	1

1, 2 and 3 are correlation levels with weightings as Slight (Low), Moderate (Medium) and Substantial (High) respectively.

CL3013 BIOMASS CONVERSION TECHNIQUES L T P C
3 0 0 3

OBJECTIVES:

- To enable the students to understand the classification of biomass and composition of biomass.
- To enable the students to understand different type of pre-treatment techniques.
- To impart knowledge on various methods of bio energy generations.
- To impart knowledge on the various biomass conversion techniques.
- To enable the students to understand the concept of bio refinery process.

UNIT I INTRODUCTION 9

World energy scenario, consumption pattern, fossil fuel depletion and environmental issues, Biomass availability and abundance, Biomass conversion processes – Biological – Thermal – Chemical – Hybrid conversions – Application of biomass conversion products – Biomass properties for conversion process – Physical properties, Proximate, Ultimate and heating value analysis.

UNIT II BIOMASS PRETREATMENT 9

Barriers in lignocellulosic biomass conversion, role of pretreatment in bioenergy conversion, pretreatment technologies such as chemical, physical and physic chemical methods, hybrid methods, Torrefaction – products obtained – properties of torrified biomass – Physical and chemical – composition changes – torrefaction as pretreatment process, Briquetting: types of Briquetting – merits and demerits.

UNIT III BIO FUEL GENERATION 9

Bioethanol and Biobutanol generation from lignocellulosic biomass, microorganisms for fermentation, current industrial ethanol production technology, cellulases and their role in hydrolysis, advanced fermentation technologies, ABE fermentation pathway and kinetics, product recovery technologies. Biohydrogen generation, metabolic basics, feed stocks, dark fermentation by strict anaerobes, facultative anaerobes, thermophilic microorganisms, integration of biohydrogen with fuel cell; fundamentals of biogas technology, fermenter designs, biogas purification, methanol production and utilization.

UNIT IV BIOMASS CONVERSION TECHNIQUES 9

Biomass combustion Process, Biomass gasification – chemistry – types of gasifiers – gasifier design, Biomass Pyrolysis process, various reactor used for biomass combustion, Gasification and Pyrolysis process. Factors affecting biooil, biochar production, fuel properties, bio-oil upgradation. Biodiesel: Diesel from vegetable oils, microalgae and syngas; transesterification; FT process, catalysts; biodiesel purification, fuel properties

UNIT V BIOREFINERY 9

Basic concept, types of biorefineries, biorefinery feed stocks and properties, economics, Concept, corn/soybean/sugarcane biorefinery, lignocellulosic biorefinery, aquaculture and algal biorefinery, waste biorefinery, hybrid chemical and biological conversion processes, techno- economic evaluation, life-cycle assessment.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

CO1: Classify types of biomasses and estimate the composition of biomass.
CO2: Explain different type of pre-treatment techniques.
CO3: Analyze the various methods of bio energy generations.
CO4: Describe the various biomass conversion techniques.
CO5: Assess the concept of bio refinery process.

REFERENCE BOOKS:

1. Sergio C. C. Introduction to Biomass Energy Conversions , First Edition, CRC Press, 2019.
2. David .B, Bio Energy Technology Thermodynamics and costs, Prentice Hall Europe, 1984
3. Sergio C. C., Introduction to Renewable Energy Conversions, CRC Press,2019.
4. Were Ko-Brobby C. Y., Hagan. E. B., Biomass Conversion and Technology, John Wiley & Sons, 1996
5. Mahaeswari, R.C. Bio Energy for Rural Energisation, Concepts Publication,1997

Course Articulation Matrix:

Course Outcomes	Program Outcomes					
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	3	2	2	1	1	1
CO2	3	2	2	1	1	-
CO3	3	2	-	1	-	1
CO4	3	2	2	1	1	1
CO5	-	2	2	1	1	-
Average CO	3	2	2	1	1	1

1, 2 and 3 are correlation levels with weightings as Slight (Low), Moderate (Medium) and Substantial (High) respectively.

EV3051 ELECTROCHEMICAL ENVIRONMENTAL TECHNOLOGY

L	T	P	C
3	0	0	3

OBJECTIVES

- To enable the students to understand wastewater characteristics and its importance
- To enable the students to understand basic mechanism in electrochemical cell
- To facilitate the students to learn basic electrochemical techniques to treat the gas, liquid and soil pollutant.
- To impart knowledge about different electrochemical reactors in treating wastewater

- To make the students analyze the application of electrochemical engineering in various industries

UNIT I ELETROCHEMISTRY 9

Definition and classification of pollutants, Physical and chemical Characteristics of wastewater, method of pollutants analysis role of sensors in environmental pollution. Introduction to Electro chemistry and Electrochemical Engineering. Electrochemical potential- Butler-Volmer, Tafel equation

UNIT II ELECTROCHEMICAL PROCESS AND ITS IMPORTANCE 9

Conventional methods for pollution control, incinerator, pyrolysis, air stripping, microbial treatment, precipitation coagulation, adsorption, membrane process. Advanced techniques of pollution treatment, Direct electro oxidation, Indirect electro oxidation, , Advantages of Electro oxidation Process, pollutant treatment using electro oxidation process, Electro coagulation process, Advantages of electro coagulation process, Electro flotation process, Application of electrochemical process for waste water treatment.

UNIT III PHOTOELECTROCHEMICAL REACTOR 9

Comparison of Chemical and Electrochemical Process- Production of hydrogen by water electrolysis. current efficiency, selectivity and energy consumption for electro organic synthesis. Photo- electrochemical cells for conversion of light energy to electrical energy- Photo electrochemical Conversion mechanism. Pollutant treatment using photo electrochemical reactor

UNIT IV TYPES OF ELECTROCHEMICAL REACTOR 9

Electrochemical reactors; two dimensional and three dimensional electrodes; Tank cell- Filter press cell-Packed bed – Fluidized bed electrochemical reactor-Applications; Batch; Continuous Stirred Tank Electrochemical Reactor and Plug flow electrochemical Reactor-Design Equation. Modeling of batch with recirculation, Electro oxidation-Electro coagulation, Application of electrochemical reactors for waste water treatment.

UNIT V HYBRID ELECTROCHEMICAL REACTOR 9

Application of AOPs for VOC reduction, biologically toxic or non-degradable and odour treatment, Case studies - textile , pharmaceuticals and petroleum industries Characterization techniques XRD, SEM,TEM,UV-DRS,FTIR

TOTAL: 45 PERIODS

COURSE OUTCOMES

CO1 Report the physical and chemical characteristics of wastewater and their measurement
CO2 Discuss basic electrochemical engineering concept to treat the industrial pollutants.
CO3 Compare various photo electrochemical method for treating pollutant
CO4 Classify various electrochemical processes in wastewater treatment.
CO5 Analyze various hybrid electrochemical reactors used in industries.

REFERENCE BOOKS

1. Scott, K., “Electrochemical Process for Cleaner Technology”, Academic Pres, 1990.
2. Kirkwood, R. C. And Longley, A.J., “Clean Technology and Environment”, Chapman & Hall, 1995.
3. Rajeshwar, K. and Ibanez, J.G., “Environmental Electrochemistry”, Academic Pre, 1997.
4. Pletcher, D., and Walsh, F., “Industrial Electrochemistry”, 2 Edition Chapman and Hall, 1990.
5. Keith B.Oldham, Jan C Myland,” Electrochemical Science and Technology, Fundamentals and applicaton”, Wiley 2011.

COURSE ARTICULATION MATRIX

Course Outcomes	PROGRAM OUTCOMES					
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	1	2	2	1	2	2
CO2	2	2	2	2	2	2
CO3	2	2	2	2	2	2
CO4	2	2	2	2	2	2
CO5	2	2	2	2	2	3
AVERAGE CO	**1.8**	**2**	**2**	**1.8**	**2**	**2.2**

1, 2 and 3 are correlation levels with weightings as Slight (Low), Moderate (Medium) and Substantial (High) respectively.

CL3054 INDUSTRIAL INSTRUMENTATION **L T P C**
3 0 0 3

OBJECTIVES:

- To enable the students to understand importance and measuring methods of various measurement parameters.
- To enable the students to understand and apply suitable instruments for measuring temperature, humidity and others.
- To enable the students to apply suitable analytical instruments for analyzing different samples.
- To enable the students to understand the necessity of controllers and sensors in measuring devices.
- To enable the students to analyze the industrial application and positioning of the measuring instruments.

UNIT I INTRODUCTION 9

Introduction – Variables, Units & standards of measurement, Measurement terms – characteristic. Data Analysis - why are the measurements of these parameters important in industry? Different methods for measurement of motion parameters: Displacement, velocity, acceleration, vibration, torque, force etc. Measurement of straightness, flatness, roundness and roughness. Typical case study/design example: Instrumentation system for motion measurement in industry.

UNIT II MEASURING INSTRUMENTS 9

Process Variables Measurement–Temperature systems– Thermocouples, Thermo resistive system, Filled-system thermometers, Radiation thermometry, Location of temperature measuring devices in equipments, Pressure system – Mechanical pressure elements Pressure Transducers and Transmitters, Vacuum measurement, Resonant wire pressure Transducer, Flow system – Differential producers, Variable area flow meters, Velocity, vortex, mass, ultrasonic & other flow meters, positive displacement flow meters, Open – channel flow measurements, Force systems, Strain gauges Humidity Moisture system, Humidity Measurement, Moisture measurement system, Rheological system, Viscosity measurement, Radiation system, Nuclear radiation instrumentation.

UNIT III ANALYTICAL INSTRUMENTS 9

Analytical instrumentation – Analysis instruments, Sample conditioning for process analyzers, X-ray Analytical methods, Quadrupole mass spectrometry, Ultra violet Absorption Analysis, Infra-red process analyzers, Photometric reaction product analyzers, Oxygen analyzers, Oxidation – reduction potential measurements, pH measuring systems, Electrical conductivity and Resistivity measurements, Thermal conductivity, gas analysis, Combustible, Total hydro carbon, and CO analyzer, Chromatography

UNIT IV CONTROLLERS AND SENSORS 9

Fundamentals of Automatic process control – Control algorithms-Automatic controllers – Electronic controllers -Electric controllers (Traditional) - Hydraulic controllers – Fluidics - Programmable controllers. Sensors, Transmitters and control valves - Pressure, Flow, Level, Temperature and Composition sensors, Transmitters, Pneumatic and electronic control valves, Types, Actuator, accessories, Instrumentation symbols and Labels.

UNIT V INDUSTRIAL SAFETY AND SPECIFICATIONS 9

Safety: Introduction, electrical hazards, hazardous areas and classification, Non-hazardous areas. Enclosures – NEMA types, fuses and circuit breakers, protection methods: purging, explosion proofing and intrinsic safety. Specification of instruments, preparation of project documentation, process flow sheet, Instrument index sheet, Instrument specification sheet, panel drawing and specifications.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

CO1 List different process variables and their measurement units.

CO2 Recognize and recall the principle and working of various process variable measuring instruments.

CO3 Describe the principle, working and range of various analytical instruments.

CO4 Explain the role of controllers and sensors in industrial instrumentation.

CO5 Rate the need of safety and specifications in Industries.

TEXT BOOKS:

1. R.K.Jain, "Mechanical and Industrial Measurements", Khanna Publishers, New Delhi.
2. C. D. Johnson, "Process Control Instrumentation Technology", PHI.
3. S.K. Singh, "Industrial Instrumentation and Control", Tata McGraw Hill Publishing Ltd., New Delhi.
4. Measurement Systems, Ernest O Doebelin & Dhanesh N Manik, McGraw Hill Education; 6 edition (July 2017).
5. Principles of Industrial Instrumentation, D Patranabis, McGraw Hill Education; 3 edition (July 2017).
6. A Course in Electronic Measurements and Instrumentation, A.K. Sawhney, Dhanpat Rai & Co. (P) Limited (2015).
7. Instrumentation, Measurement and Analysis, B. C. Nakra and K. K. Chaudhary, McGraw Hill Education India Private Limited; Fourth edition (1 August 2016).

Course Articulation Matrix:

Course Outcomes	**Program Outcomes**					
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	3	3	3	1	2	2
CO2	3	3	3	1	2	2
CO3	3	3	3	1	2	2
CO4	3	3	3	1	2	2
CO5	3	3	3	1	2	2
Overall CO	3	3	3	1	2	2

1, 2 and 3 are correlation levels with weightings as Slight (Low), Moderate (Medium) and Substantial (High) respectively

PP3052 **PIPING AND INSTRUMENTATION** **L T P C**

3 0 0 3

OBJECTIVES:

- To enable the students to learn the key concepts in piping and instrumentation of process plants.
- To enable the students to Integrate the piping drawing with the different components and process equipment's.
- To enable the students to Carry out the sizing calculations and develop the drawings
- To impart knowledge on the importance of safety and implement the control systems
- To enable the students to Develop the P&ID drawing with all basic requirements

UNIT I BASICS OF P&ID 9

Block flow diagram, process flow diagram, symbols, P&ID, P&ID symbols, line and valve numbering concept, equipment identification, detailed engineering of the process. Introduction to piping, Evolution of piping, Manufacturing methods, Piping materials and selection, Pipe dimensioning, Schedule numbers, Common piping abbreviations, Major organizations for standards, Commonly American code in piping ASME/ANSI, Common abbreviations.

UNIT II COMPONENTS AND EQUIPMENTS 9

Design principles, insulation concept, manual valves and automatic valves, ease of maintenance, pumps and compressors, pressure relief devices, heat transfer units, utilities, plant interlocks and alarms, stress analysis.

UNIT III SELECTION AND DIAGRAMS 9

Types of fluid flow, Friction factor, line sizing, pressure drop and velocity calculation, selection of material under various condition, codes and standards, selection of pipe fittings, flanges, fasteners, and gaskets. Piping isometrics, general arrangement drawings-sections/elevations/ detail drawings, plot plan procedures, vendor data drawings, Case studies.

UNIT IV CONTROLS 9

P&ID controls, Distributed Control Systems, signal lines, Selection of instruments - pressure, temperature, flow. P&ID for the given problem statement.

UNIT V SAFETY AND COST ANALYSIS 9

Final Control Elements; safety systems-application of P&ID in HAZOP, what – if, Fault tree analysis, Event tree analysis, & Risk analysis, Management of Change, cost approach. Practice & produce P&I diagrams using software packages during the period of the course. Occupational Safety and Health Administration (OSHA) - OSHA 29 CFR 1910.119

TOTAL: 45 PERIODS

COURSE OUTCOMES:

CO1: Classify the materials, codes & standards used for piping the process plants.

CO2: Apply the piping design principle & importance of utilities in industrial process plants.

CO3: Analyze the isometric drawing and general arrangement drawings.

CO4: Appraise the importance of safety control systems during piping instrumentation.

CO5: Construct a complete Process & Instrumentation Diagram with effective plant wide control strategies using appropriate heuristics and its application.

REFERENCE BOOKS:

1. Piping Handbook, 6 th edition, M.L. Nayyar, P.E., Mc Graw-Hill, Inc
2. Piping Design Handbook edited by Johan J McKetta, CRC Press, 1992.

3. Luyben, W. L.," Process Modeling Simulation and Control for Chemical Engineers, McGraw Hill, 1990.
4. Moe Toghraei, “Piping and Instrumentation Diagram Development”, Wiley, First Edition, 2019.
5. Jagadeesh Pandiyan, “Introduction to Smart Plant(R) P&ID: The Piping and Instrumentation Diagrams (P&ID) Handbook”, APJ Books, 2010.
6. Liptak B.G. Instrumentation in process industries, Chilton book Company, 1994
7. American National Standards Institute (ANSI) - ANSI/FCI 70-2-2003 - Control Valve Seat Leakage - American Society of Mechanical Engineers (ASME) - ASME Boiler and Pressure Vessel Code. Section VIII - Pressure Vessels - The Instrumentation, Systems and Automation Society (ISA) – ISA 5.1, ISA 5.2, ISA 5.3, ISA 84.01

Course Articulation Matrix:

Course Outcomes	**Program Outcomes**					
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	3	3	3	2	1	2
CO2	3	3	3	2	1	2
CO3	3	3	3	2	1	2
CO4	3	3	3	2	1	2
CO5	3	3	3	2	1	2
Average CO	3	3	3	2	1	2

1, 2 and 3 are correlation levels with weightings as Slight (Low), Moderate (Medium) and Substantial (High) respectively